GENERAL REPORT

ON

ican Industrial Conditions

IN RELATION TO

ON AND STEEL MANUFACTURES.

BY

J. STEPHEN JEANS,

retary of the British Iron Trade Association.

I.—GENERAL INTRODUCTION AND OUTLINE.

CHAPTER I.

Recent Progress.

anagement of the British Iron Trade Association me the duty of preparing a General Report on the d by its Industrial Commission, I have naturally to than any of my colleagues. Hence, I made it my e United States to obtain as comprehensive a know- the matters dealt with in these pages. For this out 27 different works in and around the principal gineering centres, including Pittsburg, Philadelphia, and (Ohio), Youngstown, Coatesville, Birmingham Time did not allow me to visit Chicago. I had Chicago and Birmingham (Ala.), and I deemed mportant centre from the point of view of future

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Telephon No 84

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LUDWIG SCHELLER, Besitzer
Hoflieferant & Hofrestaurateur

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TELEGRAMM-ADRESSE:
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WEINGROSSHANDLUNG.

Dear Mr Carnegie

Since I heard the announcement made at the Düsseldorf meeting of your acceptance of the Presidency of the Iron [illegible]

AMERICAN INDUSTRIAL CONDITIONS AND COMPETITION.

REPORT OF BRITISH IRON TRADE ASSOCIATION COMMISSION.

American Industrial Conditions and Competition

REPORTS OF THE COMMISSIONERS

APPOINTED BY THE

BRITISH IRON TRADE ASSOCIATION

TO ENQUIRE INTO THE

IRON, STEEL, AND ALLIED INDUSTRIES

OF THE UNITED STATES.

Edited by J. STEPHEN JEANS,

Secretary to the British Iron Trade Association;

Formerly Secretary to the Iron and Steel Institute, Councillor of the Royal Statistical Society, and Member of the Royal Institution of Great Britain;

Author of "Steel: Its Manufacture and Uses," "Railway Problems," etc.

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EDITOR'S PREFATORY NOTE.

IN the course of the last few years, the attention of the Board of the British Iron Trade Association has frequently been given to the conditions under which the American Iron Industry was claiming and securing a larger share than before of the business of outside markets, and largely, as it appeared, at the present or future expense of the British Iron Industry. Again and again the Association has dealt with the issues involved in, and dependent on, this movement. The conditions of American industry formed a part of the earliest work undertaken by the Association on its establishment in 1876, more especially in relation to the tariff of the United States. In 1893, Mr. W. S. Caine, M.P., the then President, read a paper before the Association on the conditions of the American Iron Trade in relation to the Chicago Exhibition. Some years later, Mr. Franklin Hilton, M. Inst. C.E., gave to the Association the benefit of his observations during a round of visits to the leading American works of that time. The conditions of American competition have had a more or less prominent place in the Presidential Addresses of Mr. Alfred Baldwin, M.P., Sir John J. Jenkins, M.P., Mr. William Jacks, M.P., and others. The general importance of the subject, as affecting the British Iron Industry, has not, therefore, been overlooked by the Association during recent years.

Nevertheless, while the members of the iron trade of the United Kingdom, in these and other ways, were made familiar with the general scope and conditions of the progress of American competition in outside markets, and of the technical improvements that had made that competition formidable, as well as possible, there were no published documents, of recent date,

that could be appealed to as an authoritative record of the true industrial situation of the moment, and of the character and extent of the influence which that situation exercised, and was likely in the future to exercise, on one of the greatest of British industries.

It was obviously desirable that this hiatus should as far as possible be rectified, and hence, after consultation with Sir John Jenkins, M.P., the then President of the Association, I drew up a memorandum for presentation to the Board, in which I recommended the appointment of a Commission of Experts to investigate the more prominent, essential, and dominating influences that had enabled the United States to reach their present status as an iron-producing and iron-exporting country.

The Board adopted this proposal, and appointed the following gentlemen to act as Commissioners, assigning to each the subjects set against their names:—

Sheet and Bar-Mill Practice, etc.—MR. EBENEZER PARKES, M.P., West Bromwich, *President.*

Blast Furnace Practice.—MR. AXEL SAHLIN, Millom.

General Steel Works Practice.—MR. ENOCH JAMES, Wednesbury.

General Economic and Industrial Conditions.—MR. J. STEPHEN JEANS, London, *Secretary.*

The proposal was warmly supported by a number of the leading firms in the trade, who have all along manifested a lively interest in the inquiry. The Commission would have been numerically stronger than it was but for the fact that certain recognised authorities whom it was deemed desirable to appoint were unable to accept nominations to act, while others who had agreed to act were restrained from carrying out their intentions by the apprehension that the then pending strike would render it difficult to obtain as satisfactory a knowledge of actual conditions as would be

possible under different circumstances. As a matter of fact, the strike was practically over when Mr. Parkes, Mr. Sahlin, and myself reached New York on the 1st of October, and there was little readily apparent evidence of its ever having taken place.

For private reasons, Mr. Enoch James, who undertook to report on the steel industry and the steel manufacturing plants of the United States, had proceeded thither some two months before the other members of the Commission, but he was afforded the same courteous reception, and the same ready access to information, as were given to his colleagues on the Commission.

Of that reception, the members of the Commission feel that they cannot speak without such a sense of gratitude and appreciation as it would, perhaps, be difficult for those who have not enjoyed similar experiences at the hands of our American cousins to understand. The Hon. Abram S. Hewitt told the members of the Iron and Steel Institute, when they were the guests of the American Iron Industry in 1890, that they would find the latch-string on every door. We, who were not invited guests, and who were there with the avowed purpose of appropriating all the best ideas and systems we might come across in the course of our wanderings, had exactly the same experience—with one or two exceptions of so trifling a character as hardly to be deserving of notice. Speaking generally, our American friends appeared to be just as ready to impart information as we were glad to receive it, and this is true, not of managers of iron and steel works alone, but of those engaged in allied and collateral industries as well. The perfect candour and absence of reserve, the unqualified readiness with which all questions were answered, the unhesitating consent given to applications for plans and illustrations, and the unmistakable friendliness and cordiality of our reception, made it hard to believe that we had not absolutely identical interests,

instead of being keen rivals and competitors in almost every market.

Directly after their arrival in New York, the Commissioners were afforded the opportunity of explaining the object of their mission and their programme, so far as it had been formulated, to a number of the leading men connected with the American Iron Industry, including Mr. C. M. Schwab, President of the United States Steel Corporation; Mr. Geo. G. McMurtry, President of the American Sheet Steel Company; Mr. John Fritz, of Bethlehem; Mr. Baldwin, of the Pennsylvania Steel Company; Mr. Morgan, the well-known manufacturing engineer, of Worcester, Massachusetts; Mr. Charles Kirchhoff, Editor of the *Iron Age*; Mr. W. R. Webster, of Philadelphia; Mr. Colby, of the Bethlehem Steel Works, etc. The whole of these gentlemen at once notified their intention to do everything possible to forward the purposes of our mission. Mr. Schwab gave us letters to the heads of the various departments of the United States Steel Corporation, and also to the superintendents of the leading works belonging to that great organisation, directing that all information should be afforded to us that had ever been given to anyone outside the Corporation's own officials. During our stay in the United States, the same courteous gentleman more than once intimated that we had only to let him know if we desired further facilities.

In some respects, indeed, we found a highly intelligent and far-seeing recognition of the fact that our interests are identical—in the methods of dealing with labour and with transportation by land and water; in the general relations of employers and employed; in the attainment and maintenance of the highest efficiency in mines and works; and in the organisation of means for the successful cultivation of foreign trade. On these and kindred matters we always found our friends ready to exchange experiences and views.

There may, in consequence of the system adopted in their

preparation, be found an inevitable amount of duplication in these Reports. To allow each Commissioner to make his own Report was deemed the most satisfactory arrangement, and each Report has been written without reference to the others, except in regard to the subjects assigned to each Commissioner in the original scope and division of the enquiry. It will, therefore, be understood that the sole responsibility for the Report which he has written rests upon each Commissioner, and not in the least degree upon any one of his colleagues.

In the revision of this Report I have to acknowledge valuable aid rendered by Mr. Harold Jeans, Acting Editor of the IRON AND COAL TRADES REVIEW, whose knowledge of the industrial conditions of the United States, gained during an experience of some five years in the iron trade of that country, has enabled him to offer important suggestions, and supply much useful information.

It has not been deemed necessary in all cases to give references to the sources whence the facts and diagrams have been gathered, but generally it may here be acknowledged that the admirable trade and technical Press of the United States has often been of service in this regard, while the Reports of the Industrial Commission, and of the American Iron and Steel Association, furnish a store-house of facts that have been no less valuable.

The vastness of the subject assigned to the Commission, and the limited time available for the production of these Reports—which it was obviously desirable to get out as soon as possible, so that they might be an accurate reflex of actual conditions—must be our excuse for such errors and crudities as the Reports may contain.

J. STEPHEN JEANS, *Secretary and Editor.*

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ADDENDA AND CORRIGENDA.

Page 12, line 13 from bottom, for "average coke consumption," *read* "best coke consumption," the average being about 1,900 lbs.; line 11, for "70,000 per lb. of coke" *read* "70 cubic feet of air per lb. of coke."

Page 197, line 23, for "arrived at" *read* "aimed at."

Page 201, line 20, for "12,000-h.p." *read* "1,200-h.p."

Resources of U.S. Steel Corporation.

As regards the resources of the United States Steel Corporation, Mr. Schwab, in a communication dated May 26th, 1902, has intimated that the Corporation now control 1,200 miles of railway, and possess 112 ore-carrying vessels, with a combined capacity of 9,500,000 tons.

Up-to-date information as to the coking resources of the Corporation, furnished by Mr. Thomas Lynch, president of the Frick Coke Company, shows that there are 21,500 ovens in the Connellsville field proper, of which the Corporation own 14,500, in addition to 2,894 ovens owned and 3,000 more controlled in other districts. The total coal area owned by the Corporation in the Connellsville and Lower Connellsville regions is about 55,000 acres, and the total area owned by other operators throughout these regions is over 5,000 acres.

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SECTION I.—GENERAL INTRODUCTION AND OUTLINE.

CHAPTER I.

Recent Progress.

THE Board of Management of the British Iron Trade Association having assigned to me the duty of preparing a General Report on the subjects investigated by its Industrial Commission, I have naturally to cover a wider field than any of my colleagues. Hence, I made it my business while in the United States to obtain as comprehensive a knowledge as possible of the matters dealt with in these pages. For this purpose I visited about 27 different works in and around the principal iron-making and engineering centres, including Pittsburg, Philadelphia, McKeesport, Cleveland (Ohio), Youngstown, Coatesville, Birmingham (Ala.), and elsewhere. Time did not allow me to visit Chicago. I had to choose between Chicago and Birmingham (Ala.), and I deemed the latter the more important centre from the point of view of future competition.

For all practical purposes, we should probably not greatly err in assuming that the modern history of the American iron industry, in so far as it is of interest to other countries, and is calculated to affect the future place of the United States in the markets of the world, did not begin until about the year 1887. It is true that previous to that year large and rapid progress had been made in certain individual establishments, and some remarkable outputs had been obtained alike in blast furnaces and rail-mills, but the production of pig-iron had never in any one year reached six million tons, nor had the output of steel got much beyond one-fourth of what it was in the year 1900.

In the five years ending with 1890, the output of pig-iron in the United States increased by 63 per cent., and the output of steel by about 150 per cent. This was the first period of very rapid growth. When the Iron and Steel Institute visited the United States in 1890, the country was on the crest of a wave of exceptional prosperity—one of those periods of extreme and rapid advance that only appear to be enjoyed by industrial nations two or three times in a generation. The output of pig-iron had, for the first time in the history of that industry, exceeded that of Great Britain. The Southern States had begun to produce pig-iron on a relatively large scale, and throughout Kentucky, Alabama, Tennessee, Georgia, and Virginia, one heard only of the splendid future that lay before the iron and steel industries. The McKinley Tariff opened up to home manufacturers the prospect of the establishment of new branches of the trade, as well as that of the expansion and consolidation of the trade already secured. Plans were being projected for new enterprises on a scale of great magnitude, under the impression that the "manifest destiny" of the States was to continue its career of rapid development and unalloyed prosperity.

Special Reasons for Economy.

In the course of my inquiries I found that, apart from the general tendency of the engineers and other sections of the community in the United States to design and contrive, wherever possible, with a view to the economy of labour, there were special reasons for the remarkable development of labour-saving methods and appliances between the years 1892 and 1896 which are entitled to consideration, as pointing to possible movements of a similar character in our own or other countries.

In common with the rest of the iron-making world, the United States passed through a period of almost unexampled difficulty during the years mentioned. Prices fell to a lower point than had ever before been known in the history of American industry. The natural enterprise of the American iron-making community was overdone. At no previous period had so many new plants been brought into operation as in the years 1888 to 1893. The evolution of methods for the cheapening of production had caused a glut of all descriptions of iron and steel. Electricity had here and there been applied to the various departments of their manufacture with notable results. Plants for the production of pig-iron, finished iron, and finished steel had been extended and increased to such an extent that the resources of production were largely in excess of the actual or likely demands. The confusion thus introduced was materially added to by the opening up of new iron ore fields, and especially of the Mesaba range, which tended to revolutionise the costs of production. The discovery and exploitation on a practical scale of this field took place only in the year 1892, and steps were almost immediately taken to ensure a large output of what was then deemed, and probably with good reason, to be the cheapest ore hitherto worked in the history of the iron trade. How cheap

this ore is compared with other competitive supplies is dealt with elsewhere.

Besides the influences that operated from within to create depression and confusion in the iron trade of the United States, there were hardly less potent influences acting from without. One of the most obvious and powerful of these was the uncertainty as to the future of the Tariff, and the fact that within five or six years there had been a number of attempts at tariff-tinkering. This is at all times a bar to prosperous trade, as it affects consumers, merchants, and manufacturers in their several ways, but in each case in such a manner as to restrict demand and reduce confidence. There was, moreover, at that time, a rapid fall in the price of silver, which naturally tended to unsteady values and restrict the demands of silver-using countries. These conditions were more or less common to all countries. The United States, however, suffered from the special cause of having the silver question raised as a national issue, and from having a party of unknown influence and unascertained resources pledged to insist on the currency of the country being established on a silver basis.

Still other potent causes contributed to the serious depression of the period in question, including, in the United States in particular, the adverse circumstances of the majority of the railroads of the United States, which destroyed confidence in American railroads as investments, and restricted their development; the vast increase in the available supply of bread-stuffs, which tended to reduce agricultural values, and to leave agriculturists in a position which did not admit of their making purchases of machinery, etc., on a large scale; and the collapse of numerous projects for the booming of new towns in which considerable capital had been invested, causing the loss of large sums of money, and discrediting further speculation and investment in this direction. Finally, there can be little doubt that in the United States, as elsewhere, the financial crisis which followed the Baring failure had a depressing and discouraging effect, and led many British investors to withdraw from American securities, whereby the gold reserves of the country were greatly reduced.

These and kindred movements were in the end counteracted by a considerable revival of demand, which increased, in the nine years ending 1899, the output of iron ore from 14½ to 24½ million tons; the output of pig-iron from less than 8½ million tons in 1891 to more than 13¾ million tons in 1899; and the output of steel from less than four million tons in 1891 to more than 10¾ million tons in 1899.

Over the whole of this period, every branch of the American iron trade was in a state of high tension. Cheaper production was the universal watchword. At mines, at blast furnaces, at steel works, in engineering shops, in foundries, in locomotive works, and in all other departments, the progress made was phenomenal. So also were the reductions in the cost of transport, both by land and water, the increase in the efficiency of labour, the activity shown in the building up of an export trade, and other features of organisation and operation hereafter referred to.

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Elements of the Inquiry.

The cost of production of iron and steel, which is the basis of this inquiry, is made up of three main elements—raw materials, labour, and transportation. No one of these matters can properly be dealt with unless in relation to the others. Raw materials, however cheap and abundant, are of little value as a basis of industrial prosperity without cheap transport and labour at a reasonable cost. Similarly, cheap labour is of little value without adequate supplies of raw materials of the right kind, plus a reasonable rate of charge for transport.

The inter-relation of these three subjects has made it necessary to devote much space to all three of them in this Report. Labour is perhaps the most fundamental of the trio, because in one form or another the ultimate cost of all commodities is mainly that of labour. In the United States, paradoxical as it may appear, we have to face conditions that make at once the dearest and the cheapest labour that is probably to be found in any part of the world—the dearest in respect of nominal remuneration; the cheapest in respect of industrial and economic results. The following pages will necessarily be largely devoted to an explanation of this apparent paradox. It is their purpose to demonstrate how American ironmasters and engineers have been able to so discipline and apply the labour at their command, as to reconcile high wages with cheap production in a degree not hitherto attained elsewhere.

There is a prevalent impression in the United Kingdom that the American iron industry has reached its present vast proportions, and has been able to make extraordinary progress both at home and abroad, mainly as a result of the cheap railroad and lake rates of freight which railways and shipping companies have placed at its disposal. It has seemed desirable to deal with this matter at considerable length, and it will hardly be questioned that the space so occupied is well filled. No American precept or example can safely be ignored in these days of stress and strain, and when it is proved that the average ton-mile rate charged for the transport of mineral traffic is not more than one-third of that paid in Great Britain, it is natural that British ironmasters should feel that there is need for a change, although they may be uncertain as to how that change can best be brought about.

The evidence here collected and published as to the resources of the United States in raw materials shows in the most unmistakeable manner that the mineral riches of that country are phenomenal, alike in quantity, in quality, and in cost. Not only is this true of one or two districts, and notably of the iron ore ranges of Lake Superior, and the coking coal district of Connellsville, but it also applies to the general economic conditions of the country—so much so, that it is difficult to undertake a journey in any direction without learning of the discovery and application of some new addition to the already ascertained sources of supply.

The Tariffs of the United States have demanded, and have received a great deal of consideration from European countries—from some with a view to the adoption, and from others with a view to the

rejection of their example. In no country has Protection been adopted in such a whole-souled manner. In no other country have the Shibboleths of Free Trade been more emphatically held at arm's length. It has been deemed desirable to deal at some length with this matter, in view not only of what has happened in the past, but also because of the possibilities of the future.

And as with the Tariff, so with the Consolidation, or so-called Trust, movements, which have occupied so large a space in the public mind during the last two or three years, and more especially since the establishment of the United States Steel Corporation in February of 1901. The Commissioners naturally found that the influence of the Corporation was almost all-pervading in certain districts, and that its future policy and its financial issues were regarded from very different aspects, and with very different ideas, by different observers. The United States Steel Corporation, in the opinion of the majority, has come to stay. As it controlled nearly two-thirds of the total iron ore, coke, pig-iron, and steel capacities of the United States at the time of its organisation, it is natural that it should be looked to as the leader of all movements of prices and wages, and the prominent part which it took in the settlement of the important labour dispute of 1901, supplied an evidence, if any were needed, that it means to use its power and influence when occasion demands that it should do so. At the same time, there is reason to believe that its power is not relatively increasing—in other words, that the production of iron and steel controlled by independent concerns, or likely to be so in the near future is, or will be, greater than that at the time of the consolidation.

It is natural that both here and on the other side of the Atlantic the vast influence and the commanding position secured by the United States Steel Corporation should have induced a degree of apprehension lest smaller plants may be swamped, and both production and price become largely a matter of monopoly. This is not, however, the opinion of the best-informed and most far-seeing men with whom I have had the opportunity of discussing the situation in the United States. That private enterprise in that country is not afraid of the Steel Corporation is made evident by the unprecedented activity that is being displayed in the establishment of new independent plants while I write. In every part of the United States plants are entering the lists to compete against the Steel Corporation, and the capacity of the private plants opposed to it to-day is probably considerably greater than it was at the time it was founded, although that was only February, 1901. A recent writer has accurately noted that small plants, well located and economically managed, are remarkably tenacious of life. It has also been observed that the best returns on American capital during the period known as the "lean years" were not generally those of the largest enterprises, but those of a few smaller firms, and those in some cases outside the range of what are known as "the cheap centres." So far as present appearances are to be trusted, the Steel Corporation is likely to make things much more easy for the smaller independent concerns by keeping up values, as they have hitherto shown a tendency to do, alike in raw materials and in finished products, and so long as this system is followed the iron

trade of Europe may escape the worst features of the so-called American invasion.

Pig-Iron Conditions.

The cost of the conditions of manufacturing pig-iron have received much attention, but no one is likely to think too much, in the course of this Report. The latest and the most advanced types of the blast furnaces in the world have been described and illustrated in the comprehensive report of Mr. Axel Sahlin, together with the accessory plant and equipment in each case, embracing blowing engines, stoves, special plant for the handling of materials, and other features of American engineering and blast furnace practice. Those who read between the lines will have little difficulty in understanding how it has come about that the typical American blast furnace of to-day, using Lake Superior ores and Connellsville coke, is able to produce an average of nearly, and, in some cases, in excess of, 500 tons of pig-iron per day, when the average output of ten years ago did not much exceed one-half of that quantity, even in the most efficient plants. No attempt has been made to discuss the knotty points involved in the old controversy of the comparative economy of "a short life and a merry one," but it will be apparent that when blast furnaces endure a "campaign" of over a million tons before re-lining—as is now not uncommon in American practice—the short life is not incompatible with a useful and relatively satisfactory career.

Such information as has been vouchsafed on the cost of production, and such further knowledge as has been gathered from a comparison of the costs and conditions of supply of raw materials, labour, and transport, appears to point to a lower cost for producing pig-iron, both in the Middle and the Southern States, than we are usually accustomed to in Great Britain. It is, however, not much more than a year ago since Sir Lowthian Bell* declared that the final cost of the materials consumed for the production of a ton of pig-iron at Pittsburg and at Middlesbrough (North Yorkshire) respectively, "may be regarded as almost identical," and he declared himself to be "sceptical as to the extent of the advantages claimed for the Pittsburg works," basing his statement on his recollection of the conditions of ten years ago, when he found as regards the minerals of the United States that "the ore mines near the lake district are 1,100 miles from Pittsburg, the coke works at Connellsville are 130 miles from the blast furnaces, which, worked out, gives an average of 777 miles. The cost of transport, based on the information I possess, gives 16s. 6d. on the ton of pig-iron." There are probably but few cases where the distance from mines to furnaces is 1,100 miles, while there are still fewer where Connellsville coke is 130 miles from Pittsburg.

Population and Pig-Iron.

An essential consideration attached to such an inquiry as this is that of how far there is a prospect of a glut, and a consequent fall of prices, following upon the recent and current abnormal activity.

* Presidental address to the Institution of Junior Engineers.

Perhaps the best test to apply to this problem is the increase of *per capita* consumption from period to period. In 1867, Mr. Abram S. Hewitt computed the population of the world at 1,000 millions, and the consumption of iron at 20 lbs. *per capita* per annum. In 1900, the population of the world was probably 1,200 millions, and the total consumption of iron in the form of pig was over 42 million tons, which gives an average *per capita* consumption for the year of close on 80 lbs., or four times the average consumption 34 years ago. In this remarkable advance there is good cause for being hopeful, if not confident, as to the scope that exists for the continued development of the iron industry in the time to come—the more so that some countries, and notably the United States, are approaching 400 lbs. *per capita* per annum, or five times the general average of mankind. Indeed, some statistical authorities, who have investigated the relation of population to pig-iron supply, have reached the conclusion that in a few years time there will be a danger of famine, unless new and hitherto undeveloped sources of supply are opened up, and Mr. C. M. Schwab recently expressed the opinion that steel has many worlds yet to conquer and will come into use for an ever-increasing variety of purposes in the future.

Spanish and Lake Superior Ore Freights.

A considerable amount of attention is given to the remarkable conditions which have enabled the iron ore traffic of the Great Lakes to provide a notable example of the cheapest water transport on an equally large scale in the world. The cost of the carriage of iron ore from the head of Lake Superior to Cleveland, on Lake Erie, was, in 1898, not much over 2s. per ton, and Mr. Colby, of the Colby Mines, on Lake Superior, and of the Whaleback Steamship Company—by which much of this work was done—has certified, before a conference of the British Iron Trade Association, that this work was done at a profit at that figure. The lowest freight hitherto charged for the carriage of iron ore from Bilbao to Cardiff or Middlesbrough in large bulk is 4s. 6d. per ton, which is fully 100 per cent. more than the American lake rate for about a hundred miles longer distance. A greater difference than this, however, more usually obtains. The more normal Bilbao-Cardiff rate is nearer 6s. than 4s. 6d. It is only fair to add that the rate of 2s. to 2s. 6d. quoted on the Great Lakes is an abnormally low one, but still it shows clearly enough what can be done. British traders have to learn how to secure equally low sea freights, distance for distance.

The Permanent Standard of American Prices.

In all inquiries into the future of American conditions and competition, a question of fundamental importance is that of whether the prices of the period 1894-98 or those of a more recent time are the more likely to be normal and permanent? Some hold that the prices of the years ending with 1898 were not natural—that with 90 cents a day for 12 hours' work, railway rates that did not cover expenses,

mineral royalties that were practically abandoned, and an immense shrinkage in the values of all iron and steel properties, conditions could not be normal, although these things are declared to have been essential to the maintenance of 6-dollar pig in Alabama, and 17-dollar rails at Pittsburg. There can be no doubt that in the United States, as in Great Britain, the serious depreciation of values in those years caused capital to flee the iron trade, and created a struggle for bare existence. It was the same with coal properties, which gave to the Pittsburg furnaces 90-cent coke over many months, a thing which, it is emphatically declared by men who ought to know, they are never likely to enjoy again. The Steel Corporation, it must be kept in mind, now supplies a mechanism for steadying values which has never before existed. That great organisation is fully aware of the ultimate value of its resources in raw materials and otherwise, and is not likely, under pressure of panic or financial stringency, to part with its property in any shape or form for less than its normal value.

Labour Conditions.

The conditions of labour in the United States is another matter that has received a good deal of attention, as being fundamental in the progress of American industries, if not also in the relative progress of some of our own. The influence of trade unionism is not nearly so strong nor so aggressive in the United States as in Great Britain. The reason is largely capable of mathematical demonstration. A recent Report by the New York Department of Labour shows that while in Great Britain at a recent date there were 1,905,000 trade unionists, there were only 1,600,000 in the United States and Canada for about twice the population, while Germany is credited with 995,000, or about one-half the British figure. The trade union is not generally recognised as a militant force in the United States, except now and again. Few employers are ready to acknowledge that it has any influence worth naming.

The almost absolute freedom of labour has been the chief instrument whereby it has won such conquests in the field of industrial economy during the last quarter of a century. In all countries industrial processes have been greatly cheapened during that period, but in America the cheapening appears to have been carried farther than anywhere else. According to figures recently made public by Mr. William Garrett, a rail roller in an up-to-date rail mill is paid less than one cent per ton for rolling, against 15 cents at a not very remote date. Within that time, again, a wire rod roller has seen his earnings per ton reduced from 2 dols. 12 cents (8s. 10d.) to 12 cents (6d.) per ton, and yet he earns larger wages at the lower figure, while 5 cents (2½d.) are paid to-day for heating billets to make wire rods, against 80 cents (3s. 4d.) during the period referred to. "If rod rollers," says Mr. Garrett, "were to receive the same wages per ton that they did twenty years ago, they would earn 424 dols. (£88) per day."

The average output per worker has in all cases been increased enormously. At the nine Edgar-Thomson blast furnaces, I was told that 1,600 men are employed for an output of 24,500 tons per week,

including all the hands employed in handling and stocking raw materials, transport, etc. This gives an average of 15·3 tons of pig per man per week, or 795½ tons per man per annum. The minimum wage paid at the blast furnaces is 1·50 dols. (6s. 3d.) per day of 12 hours. I did not get the average wage paid at these works, but Mr. A. C. Dinkey, the manager of the Homestead Works, recently testified that the average earnings of the workmen there, excluding officials, is 2 dols. 73 cents per day (11s. 3d.), while the earnings of rollers and heaters rise to 15 dols. (62s. 6d.) per day. Wages, in short, are generally so good, and the men have their futures so much in their own hands, that they have every encouragement to do the best they can both for their employers and for themselves.

The human factor and the personal equation appear to count in the United States for more than they generally do in Europe. Workmen appear to enjoy a larger measure of independence, based on the knowledge of the fact that work is more easy to obtain than in older countries, that they are able, as a rule, to save money, and are, therefore, less dependent than when living, as is not unusual in Europe, from hand to mouth, and that they are living under a political *régime* which is founded on democratic principles.

Two features of the relations of employers and employed may be named as exercising a powerful influence on the amity of their connection—the first, the encouragement and reward of workmen's inventions, and the second, the readiness with which workmen of exceptional capacity can themselves become employers and capitalists.

Foremen.

It is the invariable custom in the United States for the foreman to be appointed by the firm, and, in the vast majority of cases, he is taken from the ranks of the workmen. He is paid in all cases a fixed wage, which is usually based on a certain percentage in excess of the wages of the ordinary artisan. In an ordinary engineering shop there will generally be one foreman for each 50 to 80 workmen.

It is, of course, the general business of the foreman to set the workman his allotted work, to see that it is properly done within the proper time, to regulate the piece work prices—of which, in a large factory like the Baldwin Locomotive Works, there are some thousands—to consult with the workmen as to cases of doubt or difficulty, and either to engage and discharge men, or advise the employers thereon.

A prominent member of the trade had written me, previous to my departure, a letter, in which he suggested the probable advantages of sending out the leaders of British steel melters, rolling mill hands, and working engineers, "that they may see how differently works are operated in the United States; and I think," he added, "that if some of our foremen in the different departments also went, it would be beneficial."

This I believe to be part of the scheme that has since been formulated by Mr. Alfred Mosley, C.M.G., who, in a recent conversation that I had with him relative to this matter, informed me that he attached much importance to foremen and workmen getting correct

ideas of the progress being made, and the distinguishing conditions that prevail, in the industries of the United States generally. Of course, the typical American foreman, while he has been selected, as a rule, from the rank and file, knows perfectly well that his success or failure will be determined by the results of his own capacity and enterprise. He also knows that if his success is pronounced he stands an excellent chance, in the majority of cases at any rate, of being rapidly advanced, and that he may even hope to be asked to accept a partnership. Apart from the considerations that ordinarily weigh with the British foremen in the inspiring of confidence and taking care of themselves, the American foreman knows that if he does better than his fellows in reducing the cost and increasing the volume of work, in methodising the conditions of production, and in stimulating and, if necessary, educating the workmen to excel, he is usually certain of a special reward of some sort.

Hours of Work.

At most of the leading works engaged in the production of iron and steel in the United States, the shift or turn varies from ten to twelve hours, but in a few cases three eight-hour shifts have been successfully introduced. The most notable example of an eight-hours shift on a large scale I found at Vandergrift, where the custom is to begin the first shift at midnight and end it at 8 a.m.; the second shift begins at 8 a.m. and ends at 4 p.m.; and the third shift lasts from 4 p.m. till midnight again. The night shift on Saturday ends at 8 a.m., and the remainder of the day is devoted to changing rolls, executing necessary repairs, cleaning the mill pits, and doing other work tending to keep the plant in good order, and to obviate the need for closing every few months to carry out repairs.

At the Baldwin Locomotive Works Mr. Vauclain informed me that an average of twenty-three hours per day is the rule—divisible into shifts of ten hours in the day, and thirteen hours at night. The night hands go on at 6 p.m., and take up the work where the day hands leave off.

Generally speaking, the American workman works for ten hours per day in engineering works and factories, while in mines he is limited by custom to about nine hours; but there are no statutory enactments on the subject, and the practice varies according to the locality and the character of the work.

Scale of Operations.

The vast scale of operations is a feature of American works that cannot be paralleled elsewhere. As an example, the Homestead Steel Works may be named, which, with the Carrie furnaces and the Howard Axle Works—which are practically the same works, although different plants—paid in December last, something like £100,000 for two weeks' pay, which is at the rate of £2,400,000 a year for wages alone. The total number of hands employed at Homestead, similarly defined, is over 7,000, and the capacity of output of steel is something like 2,000,000 tons a year. One individual customer takes more than 1,000 tons a day of this output. All the other operations are on a similarly colossal scale. This fact enables the management to spread

standing charges over a large output in such a manner as to bring them down to a percentage of total cost of which probably no European works has any experience.

The Strenuousness of Labour.

One of the notable characteristics of the principal cities and industrial centres of the United States is the comparative absence of a leisured class, such as may be found in every country in Europe. The typical American appears to live only to work, and to work at something that will be a life-long career of usefulness to himself as an individual, and to the community as interested in mechanical improvements and economies. In the great manufacturing cities a man who has no regular business, who is not concerned in the development of some industry, who is not an agriculturist, a railway man, a manufacturer, or engaged in a profession, is more or less at sea. He will find it much more difficult than in any European country to get men of character, capacity, and intelligence to share his leisure in ordinary working hours, however learned it may be.

Several examples of this all but universal activity on the part of even the richest Americans were brought to my notice during my recent visit to the United States, as well as on the occasion of several previous visits. One of these was that of Mr. Cornelius Vanderbilt, jun., who is commonly spoken of as having been cut off by his father because of marrying without approval, but who, in reality, was allowed what in Europe would be deemed a very handsome fortune. Nevertheless, the young man made up his mind to create a career for himself, obtained a position in the motive power department of the New York Central Railroad, became a skilled mechanic, and among other inventions of his own has patented a special type of steel boiler which I saw being worked up into locomotives in the Baldwin Works on a considerable scale.

Another similar example is that of Mr. Jacob Astor, who occupies himself very fully with railway affairs, takes an active part in the direction of several leading American lines, and, when I was recently in the States, drove his own special locomotive engine at an unusually high rate of speed, in order to be in time for a directors' meeting at Chicago.

These facts are named because they have a most important bearing on the whole subject of American industrial prestige. Every man, however rich, must have a calling in the United States, and if leisure is not valued for its own sake, as in Europe, the natural and inevitable influence is favourable to the more rapid advance in commerce and industry of the country than that of another country where leisure and so-called "independence" are deemed of the greatest value, and are placed in the front rank as things to be aimed at and striven for. No doubt it will be argued that the American system does not provide either opportunities or a stimulus to cultivate the artistic, the literary, and the beautiful. That question, however, does not arise here, because I am only concerned in discussing the things that make for industrial supremacy, and am not called upon to recount their possible countervailing effects.

Some Notable Figures.

While we were in New York, Mr. Schwab was good enough, at a long interview which we had with him at the offices of the United States Steel Corporation, to give us several items of information as to the conditions under which that organisation carried on its business; items which are of the first importance, but which, of course, must be submitted as figures that are given exclusively on his authority. In presenting these data Mr. Schwab called for some of the cost-books of the corporation, and extracted the figures in our presence.

The first item that was discussed was the cost of producing pig-iron. On this point, we were informed that at the Edgar-Thomson

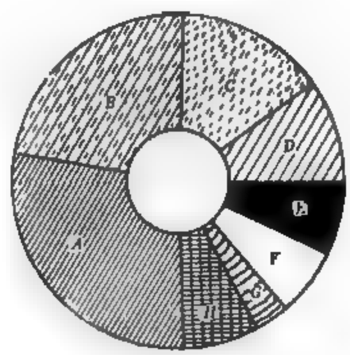


Fig. 1.—Relative Proportions of the Total Iron Ore Production of the World.

	Tons.		Per cent.
A. United States	25,086,346	=	29·24
B. German Empire	17,989,665	=	21·05
C. British Empire	15,151,617	—	17·72
D. Spain	9,397,733	—	10·98
E. Russia	4,871,000	—	5·70
F. France	4,985,702	=	5·83
G. Sweden	2,435,200	=	2·84
H. Other Countries	5,646,143	—	6·64
	85,563,400	=	100·00

Works the average coke consumption per ton of pig was 1,756 lbs.; that the average ore yield, as mined, was 55 per cent. of iron; that the volume of air blown into the furnace was 70,000 per lb. of coke, taken at the displacement of the blowing cylinder; and that the best record for labour, etc., at the blast furnace per ton of pig was $41\frac{1}{10}$ cents, which included general charges, repairs, time-keeping, and superintendents' salaries, etc.

I asked Mr. Schwab whether it had not been the policy of the Carnegie Steel Company to set aside 10 per cent. of the gross earnings for depreciation and renewals, this having been the impression that I had got as the result of an interview with Mr. Carnegie himself some years ago. Mr. Schwab replied that the company did not fix any definite percentage or amount for this purpose, but that it was

accustomed to expend what was needed from time to time, and that this was in some years more and in others less. At the same time, he believed that, taking one year with another, the expenditure on repairs and renewals would work out to nearly if not quite 10 per cent. of the total annual revenue.

As regards competition in European markets, we had a good deal of conversation with Mr. Schwab, who was keenly interested in ascer-

FIG. 2. MAP OF AMERICAN COALFIELDS (SEE APPENDIX II.).

taining the lowest cost at which it was probable that, under the most advantageous conceivable conditions, pig-iron and steel could be produced in Great Britain, and more especially in learning the lowest cost at which it would be possible to produce pig-iron, assuming that we had the best of the American furnace plants at our disposal. In his own mind, Mr. Schwab had figured that there

was a difference against England of 5 dols. 80 cents (24s. 2d.) per ton of steel ingots, compared with the lowest Pittsburg costs, while he computed the difference against us on the ore alone, assuming 15s. to be paid per ton for Bilbao ores, at about 3 dols. 10 cents (13s. 1d.) per ton of pig.

It will not be likely to be overlooked that the United States are in nearly all respects greatly different from our own country—different

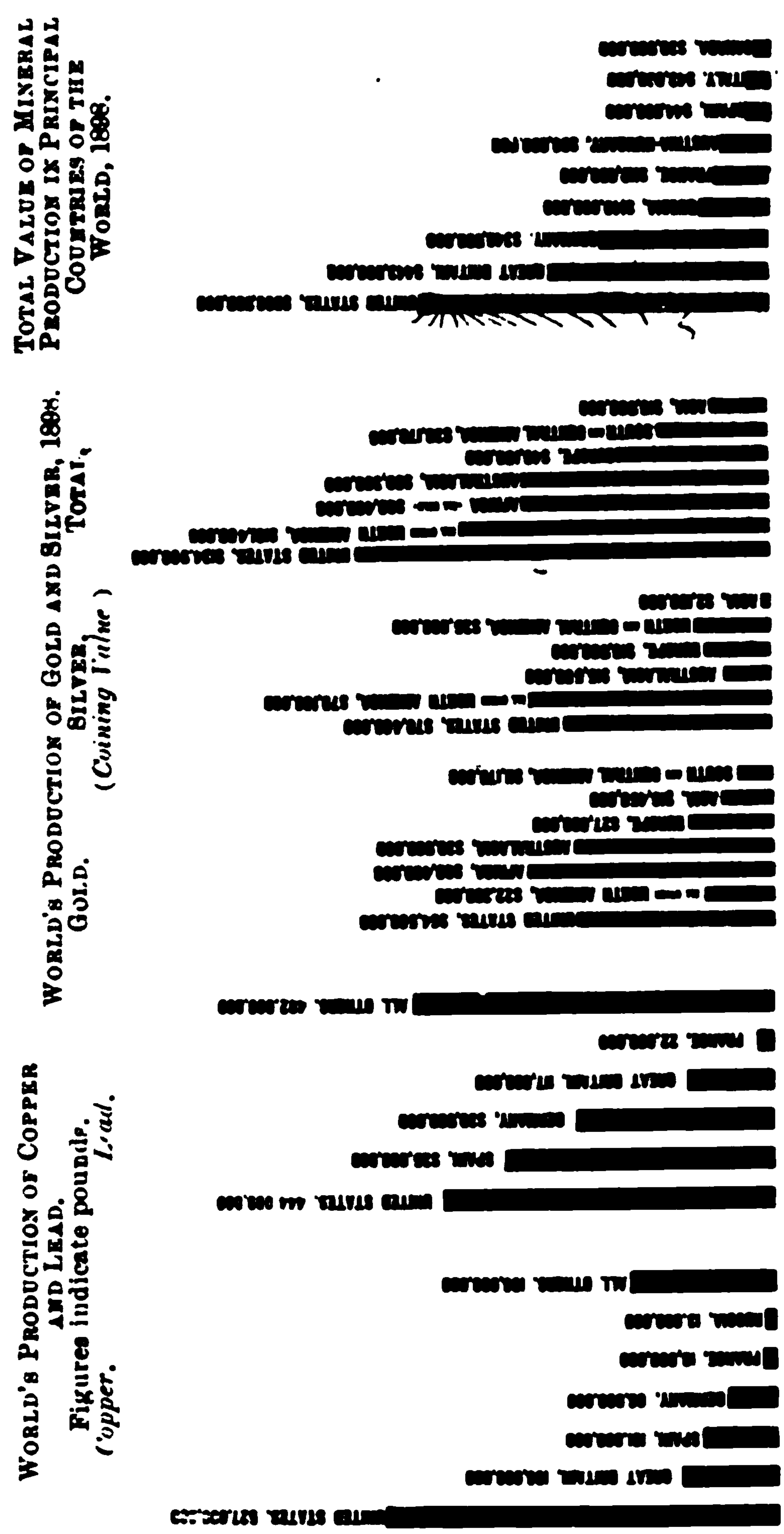
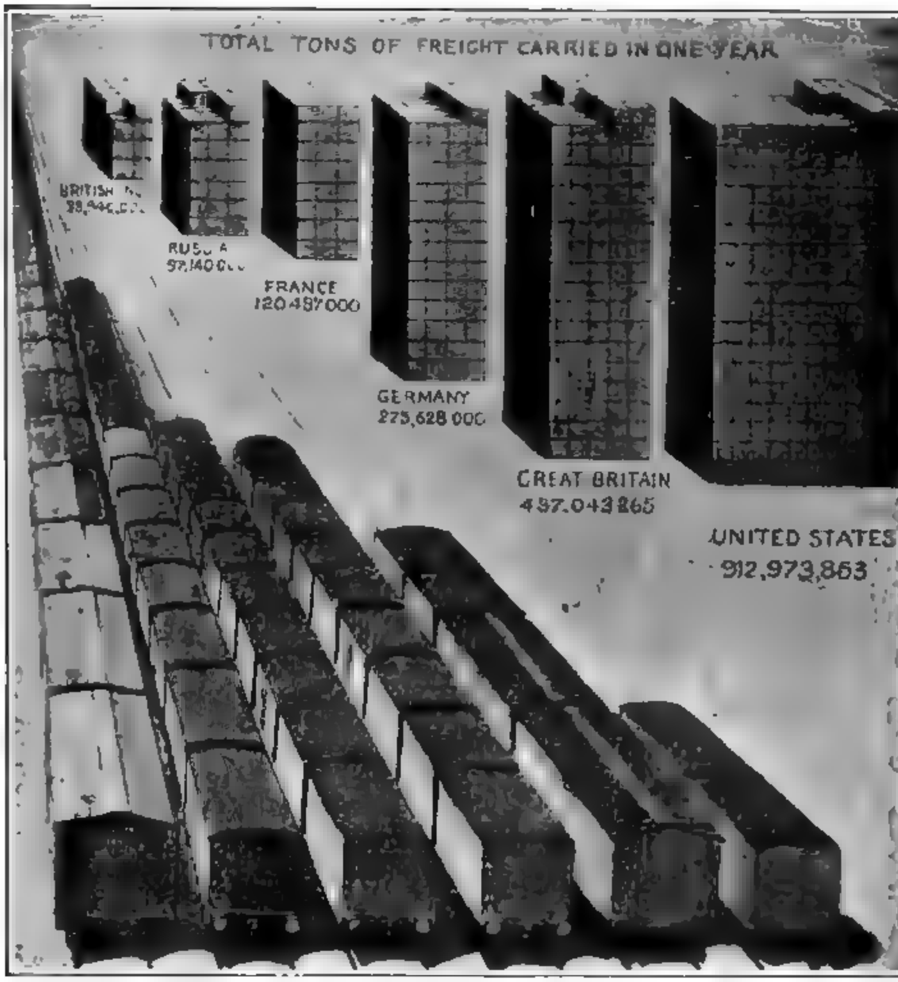


Fig. 3.—The Mineral Production of Various Countries of the World.

in their vast extent, in their unprecedentedly great requirements, in their great and rapidly-growing population, in their command of minerals of almost every kind, and in their anticipations of the future as well as their realisation of the present. Some of these differences are illustrated by the diagrams presented herewith. Fig. 1 shows the relative proportions of the total iron ore production of the world

contributed by different leading countries, but the large figures recorded for the United States omit to specify the fact that the average richness of the ore output of that country is much greater than that of any other. Fig. 2 shows the position of the different coalfields of the United States, with regard to which details will be found in Appendix II. Fig. 3 shows how the United States compares with other industrial



U.S.A. Gt. Britain. Germany. France. Russia. Brit. India.

Fig. 4.—Wagon Resources of Different Countries.

countries in regard to the output of minerals. Fig. 4 shows how the capacity of the railway wagons possessed by the United States compares with five of the next most important countries of the world, including Great Britain. Finally, Fig. 5 furnishes an indication of the marvellous development of the foundry industry of the United States, which is merely another way of saying that in that country the outlets

for the distribution of iron and steel are greatly in excess of those of any other. It will probably surprise even those who are accustomed to think and speak of big things to learn that in the United States there are no fewer than 4,600 foundries, many of them of enormous extent

FIG. 5.—MAP SHOWING THE DISTRIBUTION OF FOUNDRIES IN THE UNITED STATES IN 1898.

and the large demands which they make on pig-iron makers are of a piece with those made in many other directions. The extent to which those demands have increased of late years, and are now increasing, is dealt with elsewhere, as well as the character and extent of the provision made to meet them.

SECTION II.—RAW MATERIALS.

CHAPTER II.

Coal and Coke.

The Connellsville Coke Supplies.

MUCH of the success of the Pittsburg district from an iron and steel producing point of view is due to the location of that city in reference to its fuel supplies. Pittsburg is within 50 miles of the Connellsville coking coal region, which furnishes the cheapest coke, and almost the cheapest coal, produced on a large scale, in any part of the world. It is also within a comparatively short distance of the coalfield of Western Virginia, which supplies another variety of that mineral well suited to the manufacture of an excellent coke. Finally, the district of Pittsburg is rich in natural gas, which for a number of years has been supplied to iron and steel works at low charges, typified by 4s. for puddling furnaces, 2s. for heating furnaces, 2s. 6d. to 3s. for open-hearth furnaces, and 2s. for crucible steel furnaces, all per ton of material produced.

It is necessary to a correct understanding of the economic situation in the iron trade of the United States that the several sources of fuel supply should be dealt with, if only very briefly.

And first as to location. While Connellsville coke is within 50 to 90 miles of Pittsburg, it is much more remote from other centres to which it is supplied on a large scale. Chicago has for many years drawn the principal part of her coke supplies from this region, the average haul being about 525 miles, all by rail. Chicago also draws coke supplies from the northern coke region of Western Virginia, about 535 miles distant, and from the southern district of the same State, distant about 600 miles, as well as from Reynoldsville and Rochester districts, which are about 625 miles off. In respect to fuel supplies, therefore, Pittsburg has obviously great advantages over Chicago. Whether these advantages will continue remains to be seen. Within recent years Chicago has drawn part of her coke supplies from South-Eastern Kentucky, which is practically as near to that city as Connellsville, and it is reported, since I left the United States, that the experiments made to produce a satisfactory coke from the nearer coal mined in Illinois and Indiana have been successful.

Like the Chicago iron-making district, those of Cleveland and Youngstown, Ohio, mainly depend for fuel supply on [the Connellsville

region, but the railway companies arrange to place Cleveland, Youngstown, and Pittsburg as far as possible on the same level with regard to the cost of assembling materials at iron works, higher fuel rates being offset by lower iron ore rates, and *vice versâ*.

The vein of coal from which Connellsville coke is manufactured is of limited area, and extends from a point near Latrobe, on the Pennsylvania Railroad, in a south-westerly direction through Westmoreland and Fayette Counties, a distance of 42 miles, almost to the West Virginia State line, with an average width of 3·5 miles, covering an area of 147 square miles. Excluding barren measures, it originally contained 88,000 acres. This coal is very clean, almost entirely free from slate and sulphur, remarkably soft, easily mined, and uniform in quality and thickness. The vein averages 9 ft.

ANALYSIS OF CONNELLSVILLE COAL AND COKE.

	Coal. Per cent.	Coke. Per cent.
Water	1·130	·070
Volatile Matter	29·812	·880
Fixed Carbon	60·420	89·509
Sulphur	·689	·711
Ash	7·949	8·830

In the Connellsville district, the mines vary in depth from 50 to over 650 ft. The slopes or drifts vary from 180 to 6,000 ft. horizontal length. Some of the drifts extend for about two miles underground. There are now about 100 coal mines in the district, including drifts and slopes—mostly drifts. The coal is carried from the mines in wagons or cars, the capacity of which varies from 1¼ to 2½ tons. Iron "lorries," with a capacity of six to eight tons, are used to convey the coal from the pit mouth to the ovens. These, and the wagons below ground, are generally drawn by horses or mules, but also in more modern plants by electric traction. For underground conveyance of coal, wire rope haulage also has been introduced.

In getting the coal, the system adopted is known locally as that of the "double-heading-pillar-and-room." The quantity of coal got by this system is computed at about 90 per cent. of the whole. Rooms are driven four yards wide, leaving pillars about nine yards. The drift mines are generally self-draining. The shaft or slope mines are pumped by electrically-compressed air or steam. All the drift mines open from the outcrop.

Earnings of Workmen.—Over a series of years the average earnings of the men employed in the Connellsville region have been approximately as under:—

	Dols.	Cents.		Dols.	Cents.
Hewers	2	10	Track layers	2	10
Coke drawers	2	6	Labourers	1	35
Levellers	2	11	Machinists	2	60
Carters	1	60	Blacksmiths	2	88
Drivers (in mines) ...	2	10	Mechanics	2	60

It has been noted as a singular coincidence, that while during a period of about 20 years, the average price of Durham coke has

been about double that of Connellsville, the average earnings of the men employed in Connellsville were about double those of the men similarly employed in South Durham.

The wages in the Connellsville region have for a number of years been regulated by a sliding scale, under which, if the market price of furnace coke is 1 dol. 75 cents per ton (of 2,000 lbs.) f.o.b. cars at ovens, the wages to be paid shall be—

	Dols. per 100 bushels.
For mining and loading room coal	1·00
„ „ heading coal	1·15
„ „ wet heading coal	1·22

	Dols. per "full run.
Drivers, rope riders, and cagers	1·95
Trappers (boys)	·65
Pit Car Greasers (boys)	·90
Hitchers On	1·55
Pushers and Assistant Cagers (boys)	1·00
Haulage Engineers	2·10
Dumpers and Tipplemen	1·60

A "full run" does not exceed an average of nine hours' actual work, but all full run hands are required to remain at work until all the ovens are charged, and all the work for the day is finished, if the management so determine, and they are paid the *pro rata* rate per hour for all extra time worked over an average of nine hours per day. This extra time is computed and placed to the credit of the men at the end of each two weeks. Following are other scale rates :—

Roadmen, Horsebackmen, and Timbermen	$1·95	per day of 9 hours actual work.
Inside Labourers	1·60	„ 9 „ „
Chargers, with horses and mules...		4 cents per oven.
Chargers, with locomotives	$1·65	per day of 10 hours.
Charging Loco. Engnrs.	2·15	„ 10 „
Teamsters and Carters	1·50	„ 10 „
Yard Labourers	1·33	„ 10 „
Drawing and Loading Coke ...		55 cents per 100 bushels coal charged.
Levelling		9¼ cents per oven.
Loading and Wheeling Stock Coke into Cars ...		22 cents „
Forking Box and Stock Cars, less than 40,000 lbs. capacity ...	$1·00	per car.
„ „ „ „ 40,000 lbs. capacity	1·10	„
„ „ „ „ over 40,000 lbs. capacity ...	1·25	„
„ Small Open Top Cars from Yard	1·15	„
„ Medium Open Top Cars from Yard	1·30	„
„ Large Open Top Cars from Yard	1·60	„

Drivers, carters, and teamsters are governed by the company's rules in regard to the harnessing, unharnessing, care, and cleaning of their stock. Levellers have to attend to closing up the ovens on idle days and Sundays. Machinists, mechanics of all kinds, stationary engineers, pumpers, firemen, and all other classes and kinds of labour regularly employed, are paid "according to the work they perform, the ability acquired, and the responsibility of their positions."

The scale provides that for every advance of 10 cents per ton in the price of Connellsville coke, over and above 1 dol. 75 cents per ton of

2,000 lbs. f.o.b. cars at ovens, 2 cents per hundred bushels shall be added to the above price for mining and loading coal; 2 cents per

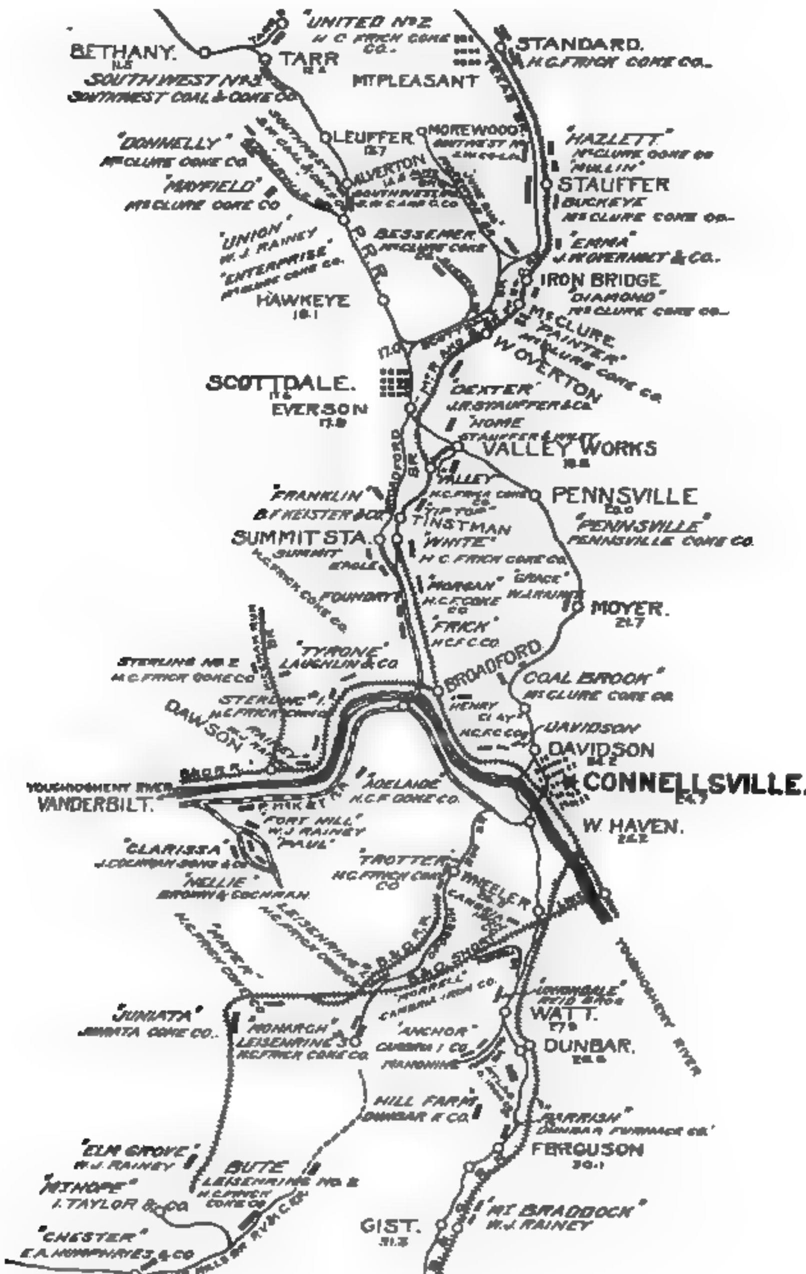


FIG. 6.—SKETCH MAP OF THE CONNELLSVILLE COAL AND COKE REGION NEAR PITTSBURG, U.S.

hundred bushels of coal charged shall be added to the above price for drawing and loading coke; one-eighth (⅛) of a cent per oven shall be added to the above price for charging ovens with horses; one-fourth (¼) of a cent per oven shall be added to the above price

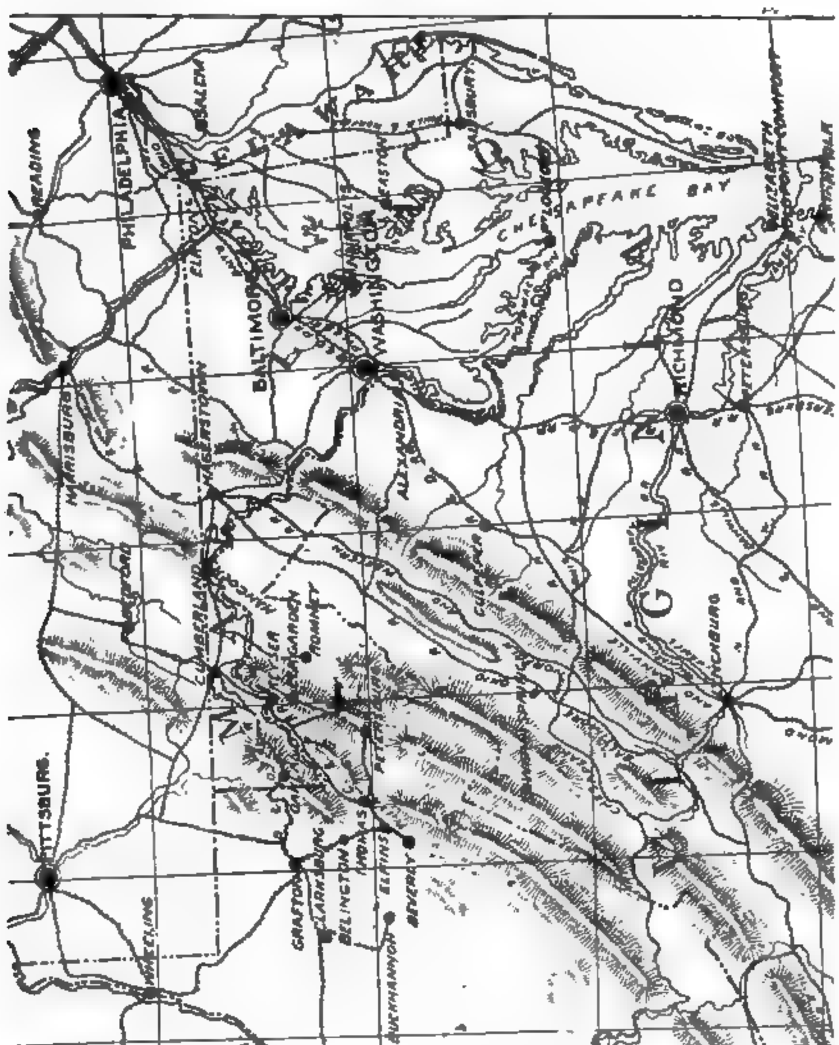


FIG. 7.—MAP OF THE COALFIELD OF WEST VIRGINIA.

for levelling ovens, and 2 per cent (2%) shall be added to all other prices of labour given in above list; payments to be made semi-monthly.

The sliding scale, as originally adopted, contained the following effective clauses as regards strikes:—

"There can be no such thing as a strike under this agreement

for any cause, and suspensions of work by the workmen at said plant shall not be allowed for any cause during the term of this agreement without the consent of the management. In case of any dispute or trouble between a workman and a boss, or any grievance growing out of or in connection with the work that any or all workmen at said plant may have, a written statement of said dispute, trouble, or grievance, signed by five (5) workmen employed at said plant, shall be given to the superintendent of said plant at his office. If the superintendent fails to make a satisfactory adjustment of the matter complained of within five (5) days after delivery of said notice to his office, it shall then immediately be submitted for settlement to three persons, one of them to be the master workman, a member of the Executive Board, or any other person the workmen at the plant may choose; one to be the owner, a stockholder or officer of the company, or any other person the superintendent of said plant may choose; and the two so chosen shall select the third, and the decision of those three, or a majority of them, shall be final and binding on both parties."

Ovens and Crushing.—The British coke manufacturer in the Connellsville region would hardly be likely to find, in the equipment, much mprovement on his own conditions. Practically, beehive ovens are he only ovens employed. They are built in both single and double rows, the former termed "bank," and the latter "block" ovens. The only material variation is in the dimensions, which range from 10 ft. 6 in. to 12 ft. in diameter, and from 5 ft. to 7 ft. high in the clear. It is usual to provide 3,000 crown and 1,200 lining bricks, with 120 bottom tiles, and 20 cubic yards of stone per oven.

More than ten years ago the H. C. Frick Coke Company introduced the crushing of coke with a view to its taking the place of anthracite coal. This system has been attended with much advantage in foundry practice. It has been found that a given weight will melt 30 to 50 per cent. more iron in 20 per cent. less time than the same weight of anthracite. The coke, of course, requires less blast than other fuel, and, as it melts iron hot and soft, more scrap can be used. The reduced quantity of slag to be dealt with, and the absence of clinker, are other advantages, while coke is easy on the cupola linings. It has been computed that while 1 lb. of coal will only melt 5 to 6 lbs. of iron, the same weight of coke will melt 9 to 14 lbs., and that while a cupola of economical size will pour off the iron melted with coke in two hours, it will take three hours when using coal.

The Steel Corporation Coke Supplies.

The cheap production of pig-iron, and consequently of other descriptions of iron and steel, in the Pittsburg district has owed much to the proximity of the Connellsville coalfield, and to the remarkably low cost and high quality of the fuel produced in that region. This obligation was recognised some fifteen years ago by Mr. Andrew Carnegie, when he invited Mr. H. C. Frick, then the largest operator in that region, to become a partner in, and to assume

a large control over, the Carnegie Steel Company. From the possessions of the Carnegie Company to those of the Steel Corporation has apparently been an easy transition. The corporation owns the stock of the Frick Coke Company, as well as that of the South-West Connellsville, the Continental, and the American Coke Companies—making four concerns in all, with a total of 18,000 coke ovens, to which about 600 more are now being added. The total number

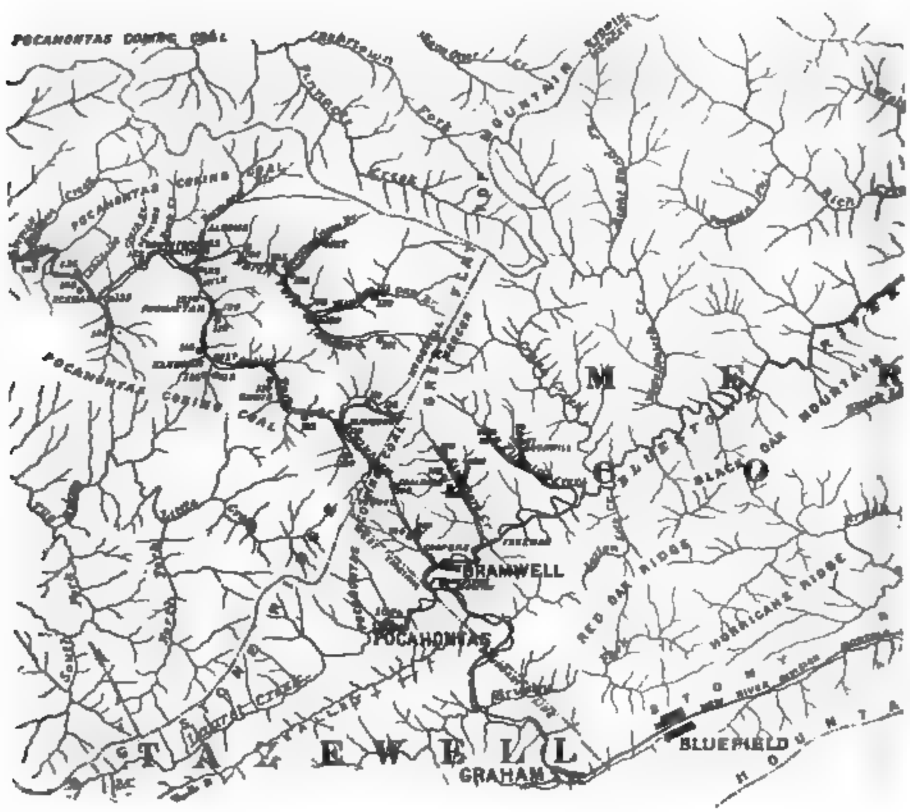


FIG. 8.—MAP OF POCAHONTAS COALFIELD.

of ovens in the whole Connellsville region, according to returns issued a few months ago, and excluding ovens in course of erection, was 20,719, so that only 2,719 ovens were available for other operators in this the most important coking field in the United States. At that date also, the Steel Corporation was erecting, through the Continental Coke Company, 900 additional ovens at Uniontown, in the same region.

These facts were put before me in the course of several interviews that I had at Pittsburg with Mr. Thomas Lynch, the President

of the Frick Coke Company. Mr. Lynch added that outside of the Steel Corporation, which owns 55,000 acres of the Connellsville coking lands, there are not more than 600 or 700 acres available in the whole region. "We own," he said, "practically the entire Connellsville coal supplies." The capacity of the coke plants under Mr. Lynch's charge is about 875,000 net tons per month. In September last, the actual output of the united plants was about 857,000 tons, which is at the rate of over 10¼ million tons of coke a year. This output is little short of being equal to the entire coke production of the United Kingdom, and is more than equal to the entire coke output of Germany. It is not, however, exclusively used by the Steel Corporation. Connellsville coke is also largely supplied for foundry purposes, and a good deal of it is sent to Chicago and other places for blast furnace use. Not far from the coal lands owned by the corporation, there are others that are suited to the production of coke, and these are of large extent, but the coke is said to be inferior.

The coke companies named are commercially carried on as independent concerns, and must "pay their way" as such, the coke supplied being charged to the Steel Corporation at a given price.

Mr. Lynch informed me that the coal of the Connellsville region can be delivered at the pit mouth for 50 cents (2s. 1d.) per net ton (2,000 lbs.), including royalty, taxes, interest on investment, and all other charges. The men are paid 37 cents per net ton for mining. The principal seam worked is 9 ft. thick, and the miners work it entirely by pick, no blasting being required, and only a minimum of skill. Hence the men employed in the mines are largely unskilled—that is, so far as previous experience is concerned. About 85 per cent. of the miners are of foreign origin, mainly Germans, Irish, English, and Scotch, but of this 85 per cent. about 60 per cent. are Poles, Slavs and Hungarians. A number of the workings are simple drifts. The deepest mine is 675 ft., but only three mines in the whole field are over 500 ft. The average hours of work are ten—from daylight to daylight. The cost of conversion into coke is about 40 cents (1s. 8d.) per ton, including loading the coke into cars.

I asked Mr. Lynch if he had formed any estimate of the probable duration of the Connellsville coalfield. His reply was that at the present rate of consumption it was computed that the Connellsville coking coal would last about 55 years. This would mean that there are still available coke supplies equal to 566 million tons, or, to put it another way, that the Steel Corporation controls about a thousand million tons of coal in that field alone.

There are no by-product ovens employed here by any of the coking concerns controlled by the Steel Corporation. The ovens are exclusively of the beehive type. I asked Mr. Lynch why by-product ovens were not adopted. His reply was that the matter had received the grave consideration of the Frick Coke Company and himself, but that they did not think it was worth while running the risk of producing inferior coke for the purpose of realising an advantage which, having regard to the remarkably low price at which they produced both coal and coke, appeared to be somewhat dubious. They

were, he added, keeping their eye upon other by-product plants in West Virginia and elsewhere, and might find occasion to alter their opinion. But Mr. Lynch does not see that they can do much better than they are now doing in producing coke at a trifle over 5s. per ton.

As regards the relation of cost of production to selling price,

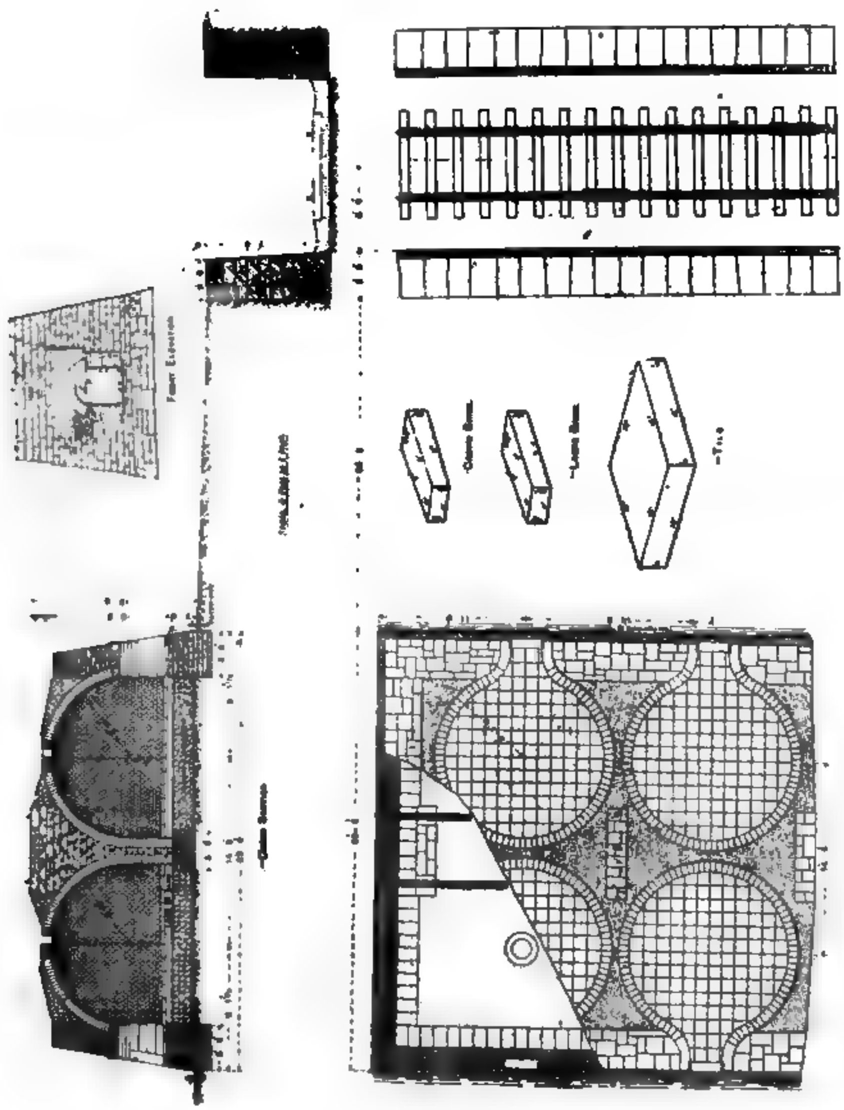


FIG. 9.—DETAILS OF CONNELLSVILLE COKE OVEN AT THE OLIVER AND SNYDER STEEL COMPANY'S WORKS, UNIONTOWN, PA.

some remarks appear to be called for. It is well known that in some previous years the average quoted price of Connellsville coke over a considerable period has been about a dollar per ton at the

ovens, and "90-cent coke" was at one time an actuality. Probably no one would maintain that coke at this price could be sold to leave any profit. My late friend, Mr. Jos. D. Weeks, who devoted much attention to the coke industry of Connellsville, and was selected by the Government of the United States to report upon it, published various ascertained statements of the cost of production, the lowest of which gave it at 1 dol. 17 cents, or 4s. 10½d. per ton, and an average of which was about 5s. 2d. per ton. At the present time (December, 1901) the selling price of this coke varies from 2 dols. to 2·50 dols. at the ovens.

As to the future, the United States Steel Corporation, as I have shown, practically holds the Connellsville coke trade in the hollow of its hand, and can almost fix its own price. Will that price be high or low? Will it be less or more than hitherto? The conservative policy adopted in the past scarcely leads to the expectation that the corporation, which is fully alive to the value of its coke property, will sell its coke at the same low rates as hitherto, the more so that the corporation, unlike some of the smaller producers responsible for the 90-cent coke period, can afford to wait its time to sell at a profit. Moreover, it is the policy of the corporation to make each department of its vast business pay its own way, and its coke properties are not exempted from this rule.

The Coking Resources and Output of the Southern States, etc.

It is hardly necessary that I should enter at length upon the coal resources of the United States. Suffice it to say that while those resources are of immense extent—computed at nearly 200,000 square miles, against less than 16,000 square miles for the United Kingdom—only a few of them provide coal that is suited to the production of a good quality of coke, and since this is the fundamental aspect of the coal question from an iron-making point of view, these districts alone need be referred to.

The most progressive district of all is that of Alabama, on which the pig-iron makers of that State rely for their supplies, jointly with the State of Tennessee. The output of coal in Alabama advanced from 380,000 tons in 1880 to 4,090,000 tons in 1890, and to 8,394,000 tons in 1900. In the latter year there were 124 mines in operation, employing 12,881 hands. Alabama now ranks fifth among the coal-producing States.

The following are average analyses of the coal of the three principal fields in this region :—

WARRIOR FIELD.

	Per cent.
Moisture	1·02
Volatile Matter	31·85
Fixed Carbon	63·82
Ash	3·31
Sulphur	0·70
	100·70

Cahaba Field.

	Per cent.
Moisture	1·68
Volatile Matter	34·13
Fixed Carbon	60·16
Ash	4·03
Sulphur	0·56
	100·56

Coosa Field.

	Per cent.
Moisture	1·43
Volatile Matter	32·21
Fixed Carbon...	60·85
Ash	4·41
Sulphur	1·10
	100·00

The total production of coke in Alabama in 1900 was 2,110,837 tons, and the average selling price is officially returned at 2·67 dollars per ton, which is the highest price recorded since 1883. Nearly 1,000 new ovens were built in 1900. At the beginning of 1901, 690 new ovens were being constructed, of which 120 were on the Semet-Solvay system.

Between 1896 and 1900, the total output of coke in the United States advanced from 11,788,773 net tons to 20,533,348 net tons.

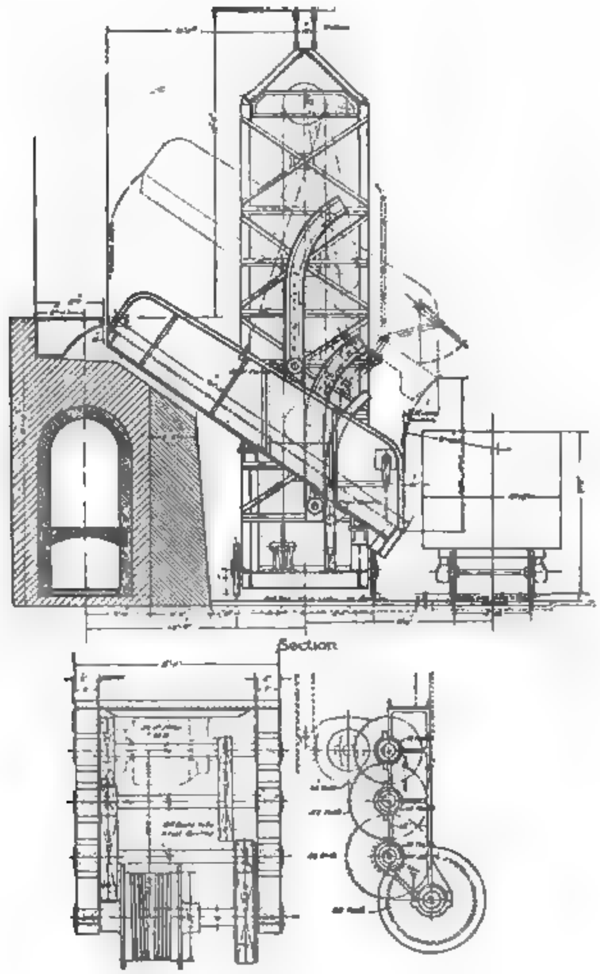
Only 73·6 per cent. of all the ovens built were in operation in 1900. In Pennsylvania the percentage in operation was 72·9; in Alabama 89·4; in West Virginia 65·6; in Tennessee 73·6; and in Virginia 78·2. At the end of 1900, 5,804 coke ovens were being built in the United States as a whole.

The following table shows the average value per ton at the ovens of the coke made in the leading States from 1896 to 1900, as given in the Government returns:—

Average Value per Short Ton at the Ovens of the Coke made in the Principal States from 1896 to 1900, inclusive.

State or Territory.	1896.	1897.	1898.	1899.	1900.
	Dols.	Dols.	Dols.	Dols.	Dols.
Alabama	2·07	2·14	2·03	2·03	2·667
Colorado	2·88	2·916	2·59	2·51	2·82
Georgia	1·276	1·28	1·56	2·30	2·849
Indian Territory...	3·50	3·45	2·833	2·96	3·99
Kentucky...	1·55	1·41	1·448	1·99	2·465
Missouri	1·65	1·50	1·42	1·93	2·52
Ohio	2·58	2·48	2·47	3·04	2·69
Pennsylvania	1·792	1·53	1·50	1·69	2·236
Tennessee	1·84	1·81	1·63	1·95	2·67
Virginia	1·509	1·40	1·317	1·73	2·137
Washington	4·04	4·42	4·27	4·98	4·797
West Virginia	1·37	1·31	1·26	1·53	2·01
Average	2·171	2·137	2·027	2·39	2·821

In 1900, there were altogether 388 coke-making establishments in the United States, which produced an average of 53,000 short tons (2,000 lbs.) of coke. Apart from Pennsylvania, which produced



Detail of Hoist Gearing.

Fig. 10.—The Seaver Electric Coke Loader.

13,798,893 tons, the principal outputs and the ovens in operation were :—

West Virginia	2,358,499 tons	with 6,729	ovens.
Alabama...	2,110,839	„ 5,838	„
Virginia	685,156	„ 1,822	„
Tennessee	475,432	„ 1,552	„

These four Southern States produced a total of 5,629,926 tons of coke, or 27 per cent. of the total coke output of the Republic.

The average output per oven in operation was 572 tons in Pennsylvania, 350 tons in West Virginia, 362 tons in Alabama, 306 tons in Tennessee, and 376 tons in Virginia.

Accompanying this chapter are illustrations of the Connellsville coking region, in which some of the outlying cokeries are omitted, but showing the location of the great majority of the principal plants (Fig. 6) ; a map of the important coking coal region of West Virginia (Fig. 7) ; a map of the Pocahontas coalfield, which is one of the most progressive and promising in the United States (Fig. 8); diagrams showing the Oliver and Snyder Steel Company's coking plant at Uniontown, Pa. (Fig. 9).

By-Product Coke.

Reference has already been made to the fact that in the Connellsville region by-product coke is almost unknown. Nevertheless, in other regions this system is making progress. At the end of 1900 there were in the United States as a whole 1,085 by-product ovens built, and 1,096 being erected, while the total output of by-product coke in that year was 1,075,727 tons. Four years previously the output was only 83,038 tons. The systems adopted are mainly those of Semet-Solvay and Otto-Hoffman. These systems do not call for special mention, as they are practically identical with those employed both here and on the Continent. At the same time, it may be remarked that attention is being devoted to the economical handling of the coke at the ovens, and labour-saving devices are being designed and put in operation to this end, such as the Seaver Electric Coke Loader (Fig. 10), which is designed to receive coke from the coking chambers of by-product coke ovens, and load it into cars standing on adjoining tracks.

CHAPTER III.

Iron Ore Resources of the United States.

The General Situation.

THE total quantity of iron ore mined in the United States in 1900 was 27,553,161 tons, and the corresponding output of pig-iron, subject to imports to the extent of less than 900,000 tons of ore, was 13,789,242 tons. So recently as 1894, the total iron ore output of the States was 11,879,679 tons, while the output of pig-iron was only 6,657,388 tons.

It is not to be supposed that the whole of the progress represented by these two sets of figures has been made in the interval. So far back as 1890 the total iron ore output was over 16 million tons, and the pig-iron output was over nine million tons.

The principal iron ore-producing localities in 1900 and in 1901 produced:—

Lake Superior Ranges.	1900. Tons.	1901. Tons.
Marquette	3,457,522	3,254,680
Mesaba	7,809,535	9,004,890
Menominee	3,261,221	3,605,449
Vermilion	1,655,820	1,786,063
Gogebic	2,875,295	2,938,155
Totals	19,059,393	20,589,237
Alabama	2,759,247	no record.
The Virginias	921,821	"
Pennsylvania	877,684	"

The Lake Superior Ranges.

In the matter of cheap and abundant iron ore supplies, the United States appear to be as richly endowed by nature as they are in respect of fuel. They do not generally have the two minerals near together. In the three or four leading centres of the trade—Pittsburg, Chicago, Youngstown and Wheeling—the iron ores and the fuel used are separated by distances varying from 800 to 1,000 miles, but this interval, which would almost appear to be prohibitive in most other countries, is but a relatively trifling drawback, in view of the extraordinary facilities provided for cheap transportation, both by land and water, elsewhere referred to.

Of the total tonnage of iron ores consumed in the United States in the year 1900, amounting to about 27½ million tons, nearly 20 million tons were mined in the five ranges of the Lake Superior region, severally known as the Mesaba, the Gogebic, the Marquette, the Vermilion and the Menominee, all of them in the States of Michigan and Minnesota.

From these several ranges the total output of iron ore in the period of 45 years, ending with and including 1900, was about 171½ million tons, which, taking into account the average richness of the ore, is the equivalent of about 103 million tons of pig-iron.

Only the Marquette and Menominee ranges had begun operations prior to 1884. Both the Vermilion and the Gogebic ranges mined their first ore in that year. The Mesaba did not mine its first ore until 1892.

In the older ranges mining was and is mostly done by shafts, and some of the mines are of considerable depth. In the Mesaba range, more than one-half of the output, which now exceeds eight million tons a year, is got by quarrying, or open-pit methods.

Of late years, the tendency has been to reduce the number of mines, and increase the output of those in operation. Thus, from first to last 87 mines have been opened on the Marquette range, of which only 22 were in operation in 1900; 68 on the

FIG. 11.—CONNEAUT HARBOUR, LAKE ERIE, WHERE THE CARNEGIE STEEL COMPANY RECEIVE AND UNLOAD THEIR ORES.

Menominee range, reduced in 1900 to 27; 47 on the Gogebic, reduced in 1900 to 25; and 36 on the Mesaba, reduced in 1900 to 29.* On these four ranges, therefore, up to the end of 1900, some 238 mines had been opened in all, of which no fewer than 135 had either been abandoned, or, for other causes, had ceased to work in 1900.

The output of the survivors varies greatly. In the Mesaba range in 1900, the greatest output from a single mine was 1,252,504 tons—

* These figures I have worked out from a very excellent and useful statement of the Lake Superior mines, published by the *Iron Trade Review*, of Cleveland, O.

the Fayal, started in 1895, and belonging to the Steel Corporation—and the smallest output was a trifle over 8,000 tons. Similar differences are found in the other ranges. The average output of the mines at work on the Mesaba range in 1900 was 269,276 tons, while in the Menominee which is a much more nearly exhausted range, the average was only 120,740 tons. The average of each range is shown in the following statement, which I have prepared from figures published by the journal already named:—

Number of Mines in Operation, Output of Iron Ore, and Average Output per Mine in 1900.

Range.	No. of Mines in Operation.	Total Output of Ore.	Average Output per Mine.
Mesaba ...	29	7,809,535 tons.	269,294 tons.
Marquette	22	3,457,522 „	157,160 „
Gogebic ...	25	3,875,295 „	155,011 „
Menominee	27	3,261,221 „	120,786 „
Vermilion...	5	1,655,820 „	331,164 „

It will be noted that there is nothing exceptional about the outputs of the Lake Superior mines, and that, speaking generally, they do not appear to enjoy the advantages that are usually attached to production on a large scale. The North Yorkshire, Luxembourg, and Alsace-Lorraine mines very often come up to the same level of average output.

The cost of production of ore varies a good deal on the different ranges, but falls to its lowest point on the Mesaba range, on account of the large quantity of ore got there by open cut. Indeed, this region has been, for several years past, the main factor in determining the cost and the conditions of supply of Lake Superior ores, has practically revolutionised the circumstances of the iron ore industry of the United States during that period, and may be regarded as mainly responsible for the low prices since prevailing. Much of the work on the Mesaba range is done by steam shovel, and the results thereby obtained, in the vastness of the quantities handled, and the lowness of the cost of production, have marked a new era in iron ore working. It has been found that one steam shovel can load on an average 2,000 tons a day, if there is a sufficient supply of cars, with a staff of 45 men. Some years ago, these men were paid from 1·30 to 1·60 dols. per day, but within the last year or two their wages have gone up to between 2 and 2½ dols. per day. It was computed in the early days of the Mesaba mines that the ore could be worked and put on cars for about 15 cents, or 7½d. per ton, not including royalty, or interest on investment, but that figure, if it ever was reached, is probably now a thing of the past.

Ore Supplies of the U.S. Steel Corporation.

At my request, Mr. James Gayley, the Vice-President of the United States Steel Corporation, who has special charge of the mineral properties of that concern, was good enough to ascertain for me the average daily wages paid at their mines in the different ranges of Lake Superior, and the quantities of iron ore produced at underground mines and at open workings, respectively. I asked for this information

because I deemed it to be important to distinguish the proportions of the total ore supply of the Steel Corporation that were being worked in the open by steam shovels and by underground mining. The results obtained are interesting. It appears that the total quantity of ore produced by the constituent mining companies belonging to the corporation in the season 1901 was 13,559,795 tons. Of this quantity 3,227,197 tons were produced in open pits, and were presumably suited to steam shovel working, in the Mesaba range. Nearly one-half of the total supply, or 6,311,165 tons in all, was produced in this range. The remainder was distributed over the Vermilion, Gogebic, Menominee and Marquette ranges in the following proportions:—

United States Steel Corporation.—Production of Ores by Constituent Mining Companies during the Year 1901.

Range.		Tons.
Vermilion	... ...	1,805,516
Mesaba	Underground, 3,083,968; Open Pit ... 3,227,197	6,311,165
Gogebic ...	... ...	1,778,143
Menominee	... ...	2,178,529
Marquette	... ...	1,486,442
Total ...	... ...	13,559,795

The total output of ore per employé in and about the mines (including the open workings) was 4·69 tons per day for the underground, and 21·53 tons per day for the open pits, so that the open pits produced per man about 360 per cent. more than the underground mines. The average cost of labour per ton in the open pits was about 5d., and in the underground mines about 2s. The details of output and wages paid for the several mines are as under—working 10 hours per day throughout:—

United States Steel Corporation.—Tons per Man per Day Produced, and Average Daily Wages Paid at the Mines of Constituent Mining Companies.

UNDERGROUND MINES.

January 1st to October 1st, 1901.

	Tons per Man per Day.		Average Daily Wages.	
Mine	Mine Labour.	Total Labour.	Mine Labour.	Total Labour
Adams ..	5·32	4·09	2·23 dols.	2·20 dols.
Spruce ..	4·80	4·02	2·26 „	2·27 „
Hull	6·01	4·71	2·36 „	2·27 „
Rust	6·05	4·98	2·13 „	2·09 „
Burt	8·16	5·23	2·17 „	2·20 „
Pillsbury ...	6·48	5·00	2·33 „	2·25 „
Genoa ...	6·03	4·81	2·19 „	2·21 „
Average	6·12	4·69	2·24 dols.	2·21 dols.

Open Pit Mines.

May 1st to October 1st, 1901.

Mine.	Tons per Man per Day. Mine Labour.	Total Labour.	Average Daily Wages. Mine Labour.	Total Labour.
Mountain Iron	40·28	32·37	2·07 dols.	2·12 dols.
Auburn ...	26·09	20·13	2·16 "	2·15 "
*Fayal	25·65	21·24	2·08 "	2·18 "
Duluth ...	16·00	12·39	2·04 "	2·04 "
Average	27·01	21·53	2·09 dols.	2·12 dols.

Mr. Gayley was also so kind as to procure for me the following statement of the possible output of the open pits of the Steel Corporation, showing that it was possible to have produced from such sources of supply about 2,506,000 tons, or 77 per cent. more had the ore been needed :—

Ore which could have been Produced by Open Pit Mines in the Season 1901.

Mine.	Tons.
Duluth Mine	200,000
Mountain Iron	1,791,098
Virginia Mines	886,414
Aetna	125,000
Fayal	1,500,000
Auburn	500,000
Sauntry-Alpena	500,000
Mahoning	156,000
Biwabik	75,000
Total	5,733,512

From these figures it may be inferred that the United States Steel Corporation has not reached the possible limits of economical ore production. It appears to have been content to pay 2s. per ton for the labour cost of producing more than 2½ million tons of ore which could apparently have been mined at about one-fourth of that amount. Put in another way, it would seem as though, by substituting the open pit iron ore that was available for the underground supplies actually worked, they could have secured the same quantity of ore for about £187,000 less—that is, assuming that the labour cost per ton of quarried ore remained the same. No doubt, however, this problem was affected by other considerations, such as the relative conditions of demand for basic and acid iron, the requirements of mixtures, etc.

Character and Extent of Lake Ores.

A good deal has been said as to the unique character and vast extent of the lake ores. To a great extent all that has been said is more or less true, but we have already seen that many mines had to be abandoned, so that the cost of working, in relation to the capital invested, must be considerable, and it is no secret that in some of

* For months of July and August. Started in July to separate Underground and Open Pit costs.

the ranges the quantity of workable ore left is by no means large. On this point, I cannot, probably, do better than quote the recent remarks of a correspondent of the *Iron Age*:—

"While the deposits of the lake region have often been characterised as inexhaustible, that term must be taken as merely relative. What seemed without limit when the production of the region was a few million tons a year is very different when set against a production

FIG. 12.—SKETCH MAP SHOWING CHIEF IRON ORE DEPOSITS OF THE UNITED STATES.

of 20,000,000 tons or more. It is not impossible that the 20,000,000-ton mark is being passed not to be receded upon except in unusual years. It was 28 years after shipments began from the historic Jackson pit that the sum of the business of the lake district reached the figure of the present year. It was but five years ago that the total reached 10,000,000 tons per annum. Now the volume of business is almost double that.

"The fancy Bessemer ores of the older ranges, excepting the Gogebic and new Vermilion fields, are practically gone. On the Mesaba,

whatever may have been said, the far greatest share of desirable Bessemers is included in the limits of one township, or close to its edge. The Menominee range has little Bessemer ore, nearly all coming from the Aragon, Loretto and Pewabic mines. On the Marquette the once famous Lake Angeline mine is fast nearing the end of its fine Bessemer ores, and there remain but a few years more of their production. All the mines of the Oliver Company on that

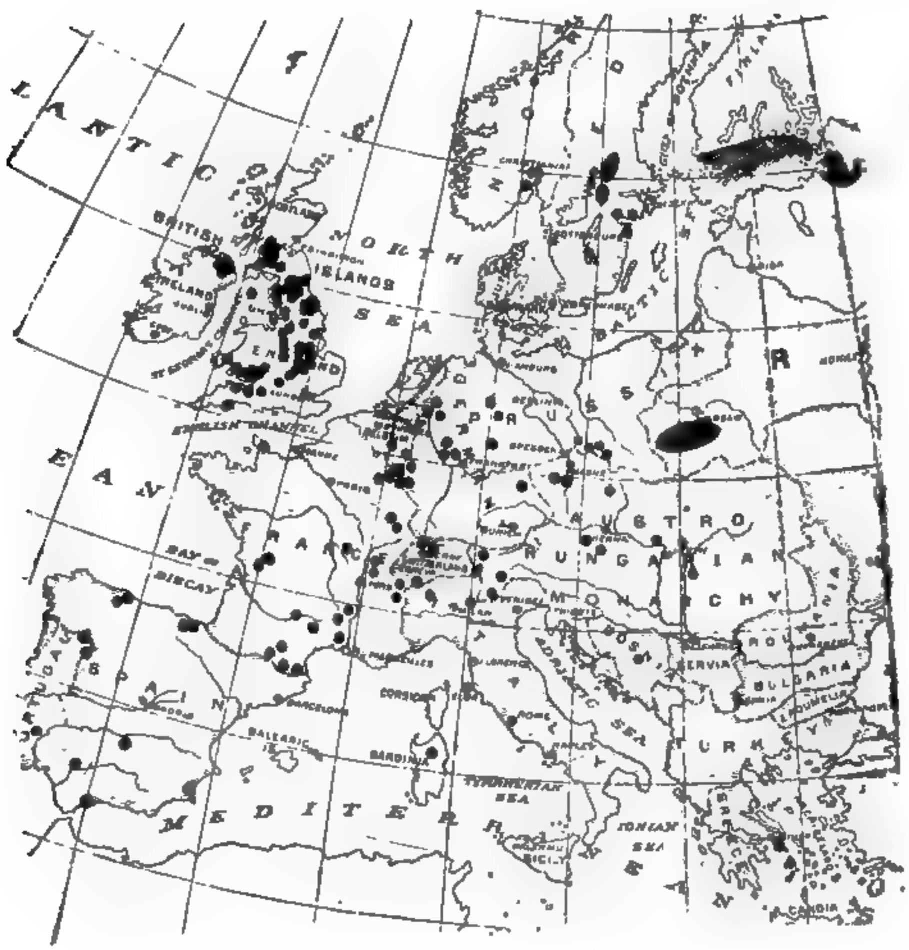


FIG. 13.—SKETCH MAP SHOWING CHIEF IRON ORE DEPOSITS IN EUROPE.

range are now classed as non-Bessemer, and the Cleveland Cliffs are disappointingly light in their Bessemer production. The ore bodies under Lake Angeline are not furnishing the percentage of high grade ores that was expected. Explorations on the range are showing few Bessemer deposits. On the Gogebic one company controls four-fifths of the deposits, if one may judge by the production, and a large share of the rest is off the market. Explorations around the old Comet

and the Puritan, Federal and Jackpot group are said to be producing good results, and there are hopes of some considerable tonnage in

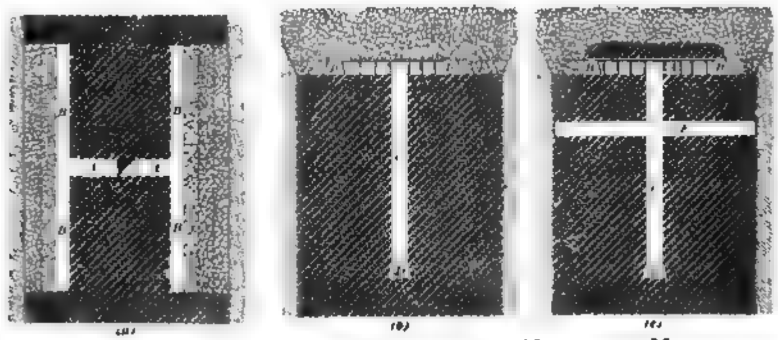


FIG. 14.—PLAN AND SECTION SHOWING CAVING METHOD OF MINING.

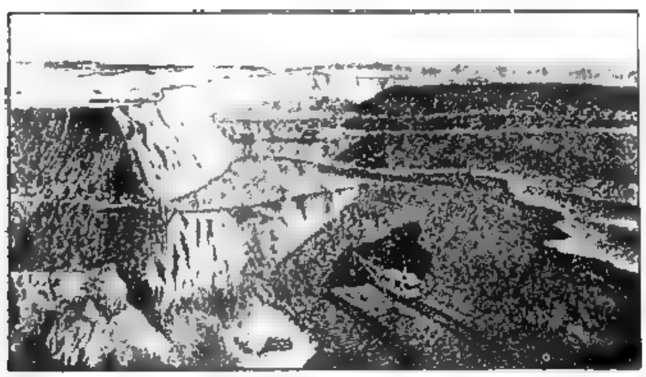


FIG. 15.—STEAM SHOVEL METHOD OF MINING.

FIG. 16.—OPEN CUT MINE WORKED BY MILLING SYSTEM.

that section. On the Vermilion, the original mine, the hard ore property at Tower is now practically a producer of non-Bessemer ores exclusively. The Chandler is reducing its output, and in a very few years will be exhausted. The new mines of the Oliver Company are large properties and are growing larger, but they have no effect on the general situation, as their ores are of a class that the Carnegie Steel Company will retain for their own use. On the Mesaba there have been some satisfactory explorations during the year, but the chief fact resulting from the immense activity on the range is that its stores of low grade non-Bessemers are very much in excess of its fancy ores. There have been found very large deposits of lean ores and of ores high in phosphorus or of ores so fine and dusty that they are discriminated against, but of high grade desirable Bessemers the discoveries can be counted quickly. It would appear that the larger deposits of the range have been found, and that subsequent work will discover smaller, perhaps more inaccessible and less valuable deposits."

Iron Ore Prices.

Over the last 30 years the quoted prices of Lake Superior ores have varied enormously. In 1873, the quoted price of Bessemer ore at the mine was as high as 12 dols. per ton, and in 1898 it had fallen to 2·35 dols. Basic ores take a somewhat lower range of values. The following tabular statement of the prices of Bessemer ore in various seasons, taken from a Report issued by the Commissioner of Mineral Statistics for Michigan, shows the average prices of ore previous to 1893, and the minimum and maximum sale prices since then, at the mine :—

Year.	Price.	Year.	Price.
1856	8·00 dols.	1890	6·75 dols.
1866	9·50 „	1891	6·00 „
1873	12·00 „	1892	5·50 „
1876	6·75 „	1893	4·00 dols. to 4·50 „
1881	9·00 „	1894	2·50 „ to 2·75 „
1886	5·50 „	1895	2·75 „ to 3·50 „
1887	7·25 „	1896	3·15 „ to 4·50 „
1888	5·50 „	1897	2·40 „ to 3·18 „
1889	5·50 „	1898	2·35 „ to 3·65 „

To the above table I add the following quotations, maximum and minimum, for the years 1899, 1900 and 1901, as recorded in the annual reports of Mr. Swank to the American Iron and Steel Association :—

	Average Prices of Ores.	
Year.	Maximum.	Minimum.
1899	3·50 dols. ...	1·90 dols.
1900	6·48 „	4·00 „
1901	4·92 „ ...	2·35 „

Some Features of Lake Iron Ore Supplies.

The great bulk—probably quite three-fourths—of all the iron ore produced in the Lake Superior ranges, is got from underground workings, and we have already seen that in the case of the mines of the Steel Corporation the labour cost of such ore is 2s. per ton. To this sum

has to be added royalty, which may now be taken at quite 1s. per ton (in some cases it is as much as 2s.; interest on investment, which will probably not be far short of another 1s., fuel; powder, and incidentals, which may be taken at 6d., although they are likely to run

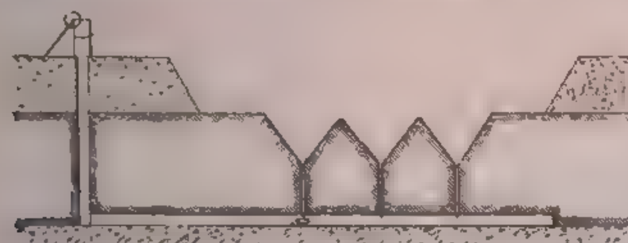


FIG. 17.—MILLING SYSTEM ON MESABA RANGE.

FIG. 18.—DRIFT READY TO CAVE.

to a higher figure in many cases. Here, then, we have, under the most favourable conditions of underground working, 4s. 6d. per ton as the cost of ore at the mine, without reckoning anything for the redemption of capital, which, in the case of these mines, should generally be taken at a pretty high figure, and probably at nearly another shilling per ton.

I have analysed the statistics of Lake Superior iron ore prices at

Cleveland, over each of the years 1899, 1900, and 1901, as given by my friend, Mr. James M. Swank, in his admirable Annual Reports to the American Iron and Steel Association. The average minimum price of the six leading descriptions at Lake Erie ports works out at 11s. 2d. for 1899, 22s. 3d. for 1900, and 18s. for 1901 ; the average for the three years having been about 17s. 1½d. per ton. This ore, however, has to be transported greater or less distances from Lake Erie ports to the blast furnaces of Youngstown, Pittsburg, the Valleys, or elsewhere, at a cost that will probably not be less than 3s. per ton, taking one locality with another, and thus we arrive at an average of approximately 20s. per ton of ore delivered at the furnaces for the same period.

There is another, and probably a more exact, way of dealing with this matter of ore cost. Up to a few years ago, the Mesaba ores occupied a relatively inferior place as a source of supply. To-day they are paramount. In 1900, the total quantity of Mesaba ore sent from the Superior region was close on 8,000,000 tons, or more than double the quantity of only four years before. In 1897, 34 per cent. of all the ores shipped from Lake Superior was of the Mesaba variety. In 1900, the percentage of Mesaba ores was 41 per cent. It is proper, therefore, to recognise the growing importance of the Mesaba ores as a source of supply, and this the more that they are the cheapest in the United States on a large scale. Analysis of the Mesaba prices for the last three years from the same source, gives an average of 13s. 4d. per ton delivered at Lake Erie ports, which is equivalent to 16s. 4d. per ton at the blast furnaces.

Conditions and Extent of Output.—The distinguishing physical conditions of the Mesaba ore make it difficult, although perhaps not impossible—on this point I heard various opinions and experience stated—to make use of it in the furnace to the extent of more than 40 per cent. or so of the total ore charge. Hence it is necessary for all smelters using this ore to mix it with the less pulverulent ores of the Marquette and other ranges. This tends to an increase of price, as no other range produces ore so cheaply as Mesaba, and, indeed, at no other range is steam shovel mining employed.

In the foregoing estimate of the cost of iron ores delivered at Pittsburg, I have taken the lowest cost of deep mining that I have heard of. On the other ranges the cost is usually much greater. Some of the mines are worked at a depth of 600 to 800 ft., and in a number of cases, Blake or other crushers are used to reduce the size of the lumps, which are often 30 in. by 33 in. The Menominee range has some special advantages. The ores are cheaply worked, although less so than the Mesaba open cut; the royalty is low (only 3d. per ton), the railway rate to a shipping port is 2s., against 3s. 4d. from Mesaba, and the lake freight to Lake Erie ports is also less than from the other upper lake shipping places. Nevertheless, the number of mines has not of late years increased. Almost the only mine of any real importance in the range is the Chapin, which I have visited. It produced 930,000 tons in 1900. Only seven mines on that range produce over 100,000 tons a year each.

Next to the Mesaba range in point of importance and output stands the Marquette, which attained its maximum output in 1899

with 3,757,000 tons, and which up to the end of 1900 had produced a grand total of 59,592,000 tons from first to last, compared with 31,400,000 tons by the Mesaba, 31,016,000 tons by the Menominee, 15,191,000 tons by the Vermilion, and 31,216,000 tons by the Gogebic

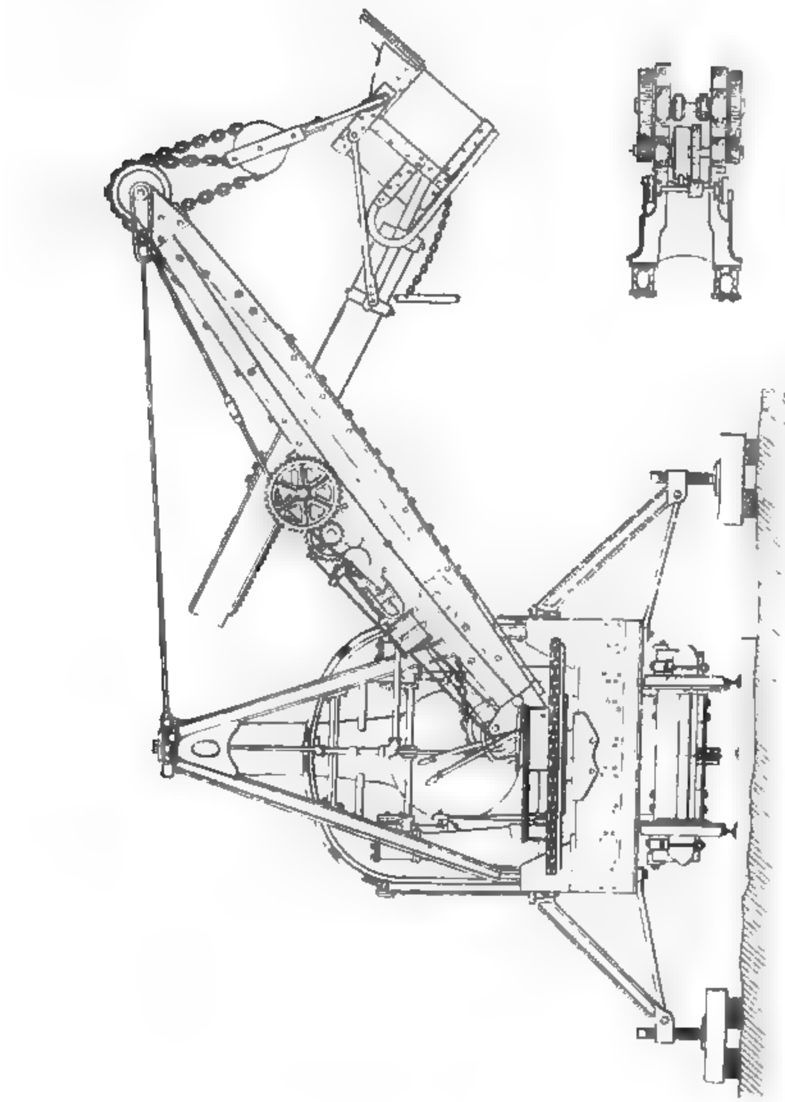


FIG. 19.—STEAM SHOVEL FOR MINING WORK.

ranges. In 1890, when I spent some days in examining this range, there were 35 mines in operation, whereas in 1900 the number had been reduced to 22. I can well remember my late friend, Dr. Mackenzie, who had a large interest in the Republic mine on this range, telling me, more than 20 years ago, of the vast profits then being

made when the ore raised was selling at 30s. to 35s. per ton. When, with my American colleagues, I took the members of the Iron and Steel Institute — of which I was then the general secretary — to Marquette in 1900, we were shown over mines which remain the chief producers to this day. Two of them eclipse all others—the Cleveland Cliffs, with an output of 881,000 tons in 1900, and the Lake Superior, with an output in the same year of 709,000 tons. The total output of this range in 1900 was 3,457,000 tons, about 50 per cent. of which was of so-called Bessemer quality. Nearly all the mines here are held in fee simple.

On the Great Lakes, the opening and closing of the navigation season—that is to say, the time over which ore can be shipped—varies considerably. Over the period 1885-1900, the earliest opening was April 11th, in 1898, and the latest May 11th, in 1888, while the earliest closing was November 29th, in 1885, and the latest December 31st, in 1888. It will be noted that the navigation season only lasts from six to seven months, and hence consumers of iron ores have to store a supply sufficient to last over the period when the navigation of the lakes is no longer possible.

Perhaps the most wonderful thing about the supplies of iron ore to American blast furnaces is the low cost of transport, having regard to the distances covered, both absolutely and relatively. If we assume the average cost of transport from the mines in any one of the Lake Superior ranges, to the blast furnaces in Pennsylvania, Ohio, or Illinois to be 1·50 dols., or, say, 6s. 3d. per ton, this will only represent a little over 1·2d. per unit on a 60 per cent. ore, which may be taken as typical, while if we assume the corresponding average cost from Bilbao to the blast furnaces in South Wales or Middlesbrough at 6s. for an average 48 per cent. ore, the transport per unit works out at 1½d. In Great Britain, the transportation cost of local ores will not exceed an average of 1s. 6d., or, assuming an average of 35 per cent. of iron, about $\frac{5}{10}$d. per unit.

The present minimum costs of mining Lake Superior ores, by pits, and delivering at Pittsburg, may be approximately as under :—

	£	s.	d.
Cost of mining	0	2	0
Fuel and incidentals	0	0	6
Royalty	0	1	0
Stocking ore, etc.	0	0	5
Interest on capital	0	0	6
Redemption	0	0	6
Railway rate to ore-dock	0	3	4
Lake freight	0	4	0
Railway rate to Pittsburg, etc.	0	4	9
Total	0	17	0

In the above figures I have assumed that the railway rate from Cleveland, or other Lake Erie port, to Pittsburg is not the figure at which the Carnegie Steel Company claim to carry the traffic, but the actual rate paid, as I am informed, by the American Steel and Wire Company. I have taken the royalty at an average

and not at the highest figure, and the lake freight is taken at a medium, and not at either the highest or lowest quotations. Indeed, it is hardly to be expected that, on an average of years, the lake freight will fall much, if any, under 4s. for an average distance approaching 800 miles. Interest on capital and redemption are the two most doubtful figures.

While the cost of mining on the Mesaba range is materially less than that of either of the other ranges, this difference is not all clear gain to the mine-owner. The cost of transportation to Lake Erie ports—the great distributing centres—is generally about 2s. 6d. per ton in favour of Marquette and Menominee ranges, while the Mesaba mine-owners have to pay from 1s. to 2s. per ton royalty, from which many mine-owners on other ranges are free, owing to their ownership of the freehold.

There are material differences in the cost of bringing the ores of the several Lake Superior ranges to their principal markets, which count in the ultimate cost of the product. Usually there has been a

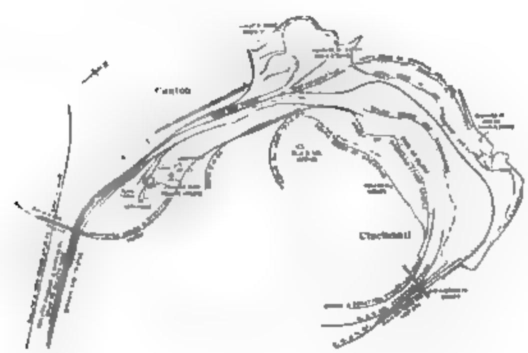


FIG. 20.—MAP OF THE BIWABIK WORKINGS, MESABA RANGE.

difference of 55 to 60 cents per ton in favour of the Menominee and Marquette ranges.

Of the ore produced in the Marquette region in a recent year about 60 per cent. was computed to be non-Bessemer. On the Menominee range almost the whole of the ore output is non-Bessemer. The Gogebic range produces ores that are practically all Bessemer. The bulk of the ores of the Mesaba range are non-Bessemer.

In 1895, when Bessemer ores were selling at Lake Erie ports at 2 dollars 30 cents to 2 dollars 50 cents, the non-Bessemer had sold at 1 dollar 75 cents. In other words, a great deal of non-Bessemer ore was then selling at a loss. It was then possible to deliver these ores in the Lehigh and Schuylkill valleys in Eastern Pennsylvania for about 5 cents per unit of metallic iron.

In the case of the Biwabik mine three steam shovels last year mined from its natural bed, in day shifts alone, 915,000 gross tons of ore. In a single month 205,000 tons were produced, and in a ten hours' shift 5,365 tons. These are probably the largest yields that have been got in the history of iron ore mining. The sketch attached

hereto (Fig. 20) shows the principal features of the mine, which consists of three 40-acre tracts of land.

Extent of Supplies.

It would clearly be a matter of considerable importance to ascertain, if it were possible, how long the existing ascertained iron ore resources of the Lake Superior region are likely to last at the present rate of consumption. This, however, it is almost impossible to compute with approximate accuracy. To begin with, the consumption is increasing very rapidly, and appears likely to continue to do so. Since 1890, the output of Lake Superior ores has more than doubled—in other words, it has increased from about 9,000,000 to more than 20,000,000 tons. If it should, as is very probable, increase by 10,000,000 tons during the next ten years, it would be

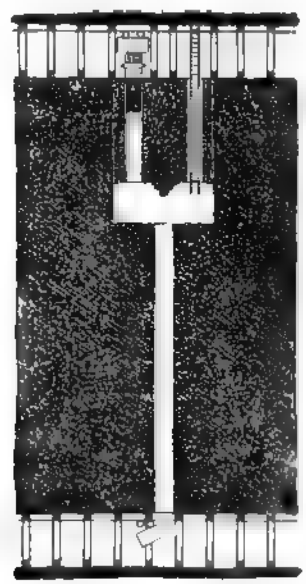


FIG. 21.—SYSTEM OF MINING AT THE CHAPIN MINE, MICHIGAN.

about 30,000,000 tons in 1910. This is, of course, an enormous drain on the more or less limited resources of the already largely exhausted older ranges. The principal source of supply, and the chief hope of the American iron trade in the future, is the Mesaba field. The utmost quantity computed to have been available in that field from first to last is 500,000,000 tons. That is the very sanguine figure adopted by Mr. H. V. Winchell,* who is very familiar with the region, and an authority on its resources. But of that estimate, about 40,000,000 tons had been worked to the end of 1901. It is probable that during the next ten years 150,000,000 more will be taken out, assuming an average of 15,000,000 tons a year for the whole period.

* Trans. Fed. Inst. Min. Eng. 1896-97. p. 544.

This would leave little more than 300,000,000 tons, dating from 1912, and if, subsequent to that year, the consumption is assumed to be, say, 20,000,000 tons a year, the whole field would only have a further life of 15 years, or approximately 25 years from the present time.

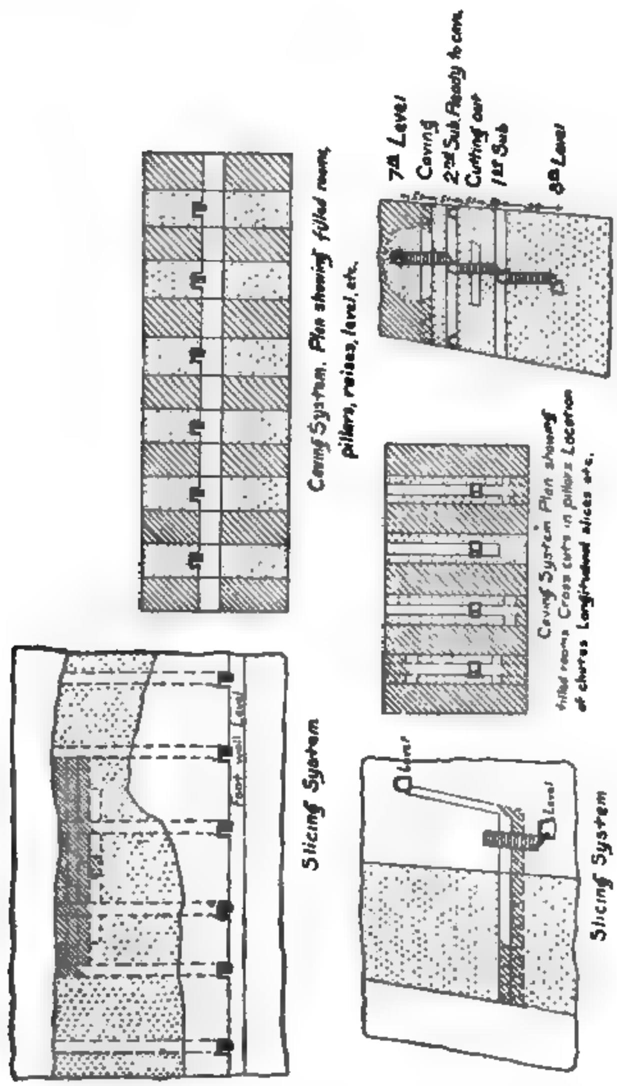


FIG. 22.—SLIDING AND SUB-DRIFT CAVING SYSTEM, CHAPIN MINE.

These are not only not improbable, but they are even likely figures, and they may, and in the opinion of some authorities will, be considerably exceeded.

While this hypothesis appears to dispose of the supremacy of the Lake Superior ranges, it is not intended to convey the impression that

the end of that supremacy will involve the finish of the available ores of the United States. It would be rash to assume that the extent of such ores has, as yet, been ascertained. Apart from the enormous known supplies in Alabama, Tennessee, Kentucky, and other of the Southern States, new fields are constantly coming to light in other regions. A friend of my own, who is an owner in the Lebanon furnaces and Cornwall mines in Pennsylvania, has told me of vast deposits in New Mexico, only just beginning to be worked, which he has himself examined. Some time ago, when travelling through the territory of Oklahoma, I was shown, at Guthrie, some specimens of iron ore taken from what I was informed was a very extensive deposit close at hand, not then or yet touched. And considerable ore bodies are known to exist in the Western and other States—so much so as to justify the anticipation that the future should witness a material development of the American iron industry both in the West and on the Pacific slope.

Southern Iron Ores.

We have already seen that, next to the ranges of Lake Superior, the chief iron ore-producing State is that of Alabama, and the supply of this State is mainly obtained in the Birmingham district, which I visited with my colleagues.

The ore supply of the Birmingham district is principally derived from the red fossiliferous ores of Red Mountain. The vein carrying this ore is about 20 ft. thick at the out-crop, and extends under cover at an angle of from 15 to 20 degrees from the horizontal to an unknown depth. Some of the slopes in the district have been driven down a distance of 1,000 ft. from the out-crop, and, so far as they have gone, no deterioration of the quality or diminution of the size of the vein occurs, and no indications point in either direction. Red Mountain carries this vein of like good quality and thickness for a distance of 10 miles north-east, and 15 miles south-west of Birmingham.

Mining ore in the district is carried on chiefly by the companies manufacturing pig-iron, or by contractors working on company property. There are, however, about 40 independent operators in the district, who mine ore from their own lands and sell to the furnace companies.

The production of iron ore in the State of Alabama, about 90 per cent. of which was mined in the Birmingham district, was:—

In 1880	171,136 tons.
„ 1885	505,000 „
„ 1890	1,897,815 „
„ 1895	2,199,390 „
„ 1899	2,627,000 „
„ 1900	2,759,247 „

Canadian Iron Ores.

During 1900 the new and highly important iron ore field of Michipicoton was opened on Canadian territory, on the N.E. shore of Lake Superior. The ore is largely non-Bessemer and of rather low grade. Between Michipicoton and the Lake of the Woods is another

new iron ore range, also in Canadian territory, known as the Atikokan, which is said to be full of promise; it is a magnetite, very low in phosphorus, and it is said that arrangements have been made for its delivery at docks to be constructed by the Ontario and Rainy River Railroad at less than the rate now charged from the Vermilion range to the lake.

Turning our attention to the Eastern Provinces of Canada, the cost of mining the Belle Isle ore is stated to be less than 30 cents a ton, and its shipment to Sydney is stated at 25 cents per ton. The miners are paid 12½ cents per hour. The cost of shipment to Europe of the Sydney pig has been computed at about a dollar per ton, but it is likely to be a good deal more than this taking one year with another. The conditions for shipment at the northern end of the island are favourable to economy. The laden cars run down an incline to a recently-erected pier, where they are automatically unloaded, either into the "pockets" constructed in the pier, or into the ship's hold.

The Wabana mine in 1900 passed into the possession of the Dominion Iron and Steel Company. This corporation purchased the property for 1,000,000 dols., in order to have in it a supply of ore for the works they have erected at Sydney, Cape Breton. The company had already acquired control of most of the coal mines in Cape Breton, and limestone abounded, so that they had two important constituents right at hand. The third, hematite iron ore, was provided by the acquiring of the Wabana mine. Belle Isle is 400 miles from Sydney, with a continuous, unobstructed deep water passage from one point to the other, the ore running into the steamer's hold from the pier at Wabana and being hoisted out at the pier at Sydney, only a few yards from the blast furnaces. Sydney is a deep water port, 2,100 miles from England, New York being 3,100 miles. Taking into account the railroad freights to the sea-board of the United States, as well as the increased cost of ocean transfer, it was not unnaturally expected that the product of the Sydney works would be able to undersell that of any American competitor in the iron centres of Europe. This anticipation has to a certain extent been justified, but it must be remembered that the Canadian pig is bounty-fed, and that commercially the results have not been entirely satisfactory to the company.

Methods of Mining on the Mesaba.

The illustrations that accompany this section include those of the system of caving on the Mesaba range (Fig. 14); of the steam shovel method of mining (Fig. 15); of an open-cut mine as worked by the milling system (Fig. 16); and of the milling system (Fig. 17); of a drift ready to cave (Fig. 18); and of the steam shovel as applied to Mesaba iron ore mining (Fig. 19). A map of the workings of the Biwabik mine on Mesaba range is given in Fig. 20; and the methods of working at the Chapin mine are illustrated in Figs. 21 and 22.

CHAPTER IV.

Mineral Royalties in the United States.

I HAVE found a prevalent idea among my own countrymen that they are burdened with an incubus, in the form of heavy royalty rents, which is not nearly so heavy or so onerous in other countries, and least of all in the United States. With other countries I do not propose to deal, but it is necessary, I think, to put it on record that in the United States royalties are now general, and that in some cases they are exceptionally heavy. The main difference between the United States and our country in this respect appears to be that the American mine-owner is, in a much larger proportion of cases than with us, not infrequently the freeholder, so that he is not called upon to pay royalty, or any equivalent for royalty, excepting the redemption of the price paid for the freehold, which, in several cases within my knowledge, has been so considerable as to represent a very material royalty rent indeed. Moreover, the freeholder who has paid a large price for his freehold always runs the risk of the more rapid exhaustion of the *corpus* than was anticipated when he embarked on an enterprise that is usually hazardous and uncertain.

Iron Ore Royalties.

In the United States it is generally and increasingly the practice of mineral workers to pay royalty rents to the owners of the soil, to whom the right to make such charges is given by the State. The payments made or charged under this head vary from 4d. to 2s. per ton. Great fortunes have been made by not a few men in consequence of having bought in the wilderness, at nominal prices, unreclaimed land under which minerals were afterwards found, the buyer either selling outright to mineral workers or charging royalties. This specially applies to the Lake Superior regions of Mesaba, Gogebic, Marquette, and Vermilion.

The following examples of the tendency to an appreciation of the value of royalties refer to the Mesaba range, and were given in the *Iron Age* some years ago, but it may be noted that since then that tendency has become more accentuated:—

"The Wright and Davis leases are 30 cents a ton, and the others are at figures that average about 27 cents. . . . . As showing the value to the owners of these tracts, may be instanced a 40-acre piece of ground belonging to W. R. Burt and leased to the Lake Superior at 30 cents a ton. Careful test borings and pittings have shown that a total of 15,000,000 tons is not too much to be placed on the property, much of which is said to be Bessemer ore. The term of this lease, like most of the others in the region, is 20 years, and it would not be too much to say that 3,000,000 dols. will be received by the owner of this small tract before the ore is mined out. . . . .

"For the lands of the great Adams mine . . . . the company are to pay a royalty of 35 cents after the first two years' work. . . The Biwabik, with not less than 20,000,000 tons of ore in all probability, is owned by a syndicate of Chicago lumbermen, and is leased at 50 cents a ton, of which the fee owners get about half. They are also owners of the fee of additional mines on the east part of the range that will likely increase their deposits of merchantable ore materially. Hill & Bliss, of Saginaw, have mines on the same part of the range from which they have taken 100,000 dols. as a bonus, retaining the fee, which it is supposed will nett them several millions during the term of lease. C. W. Yawkey, of Detroit, is owner of the fee of the Commodore and other mines being explored by A. E. Humphries and others, on which the deposits of ore run far above 10,000,000 tons, in all probability.

"The Auburn mine of the Minnesota Iron Company was bought originally from the C. N. Nelson Lumber Company, and the company retain the fee, getting a royalty of 25 to 30 cents. For the lease of this mine and the lands held under by the same deal the Minnesota Iron Company paid a bonus of not far from 400,000 dols."

The remarkable differences in the range of iron ore royalties in the Lake Superior region are indicated in the following statement of the actual royalties paid in the cases of ten Mesaba mines:—

Actual Royalties on Mesaba Ores.

Mine.	Royalty.
Auburn (Iron King)	30 cents.
Biwabik	50 „
Canton	5 „
Franklin	0 „
Hale	20 „
Minnewas	25 „
Vega (at Eveleth)	0 „
Mesaba Mountain (Oliver)	50 „
Mountain Iron	0 „
Norman	25 „

On the Menominee and Marquette ranges, the mine-owners generally control the fee simple of the mineral areas and pay no royalty. On the Mesaba range, however, the royalty payment usually ranges from 20 to 25 cents, the land not being owned by the mineral operators.

Sliding Scale Royalties.

The Cleveland Cliffs Iron Company, which controls over 50,000 acres of land in the Lake Superior iron ore district, some years ago announced a new schedule of royalties, to take effect on all those portions of the lands under its control which were thrown open for option and lease at that time. The old schedule was nominally 30 cents for non-Bessemer, 40 cents for Bessemer, and 50 cents for the higher grade of Bessemer ores. The company gave as its reason for reduction the lower range of values in the iron industry, and a consideration of the fact that the rates formerly in force were established at a period when prices were high. The sliding scale was

ostensibly adopted because it was believed to constitute the fairest possible plan. Royalties were to be based on Cleveland, or rather Lake Erie port, prices, whether governed by the market or by actual sale, and if the ore was to be delivered at any place other than Cleveland, the difference in freight rates, if any, was to be added to or deducted from such contract to determine the rate of royalty. The schedule of royalties was as follows :—

Price. From	To	Royalty.	Price. From	To	Royalty.
.... dols. ...	1·49 dols. ...	·07 dols.	2·35 dols....	2·39 dols. ...	·21 dols.
1·50 „ ...	1·59 „ ...	·08 „	2·40 „ ...	2·44 „ ...	·22 „
1·60 „ ...	1·69 „ ...	·09 „	2·45 „ ...	2·49 „ ...	·23 „
1·70 „ ...	1·79 „ ...	·10 „	2·50 „ ...	2·54 „ ...	·24 „
1·80 „ ...	1·89 „ ...	·11 „	2·55 „ ...	2·59 „ ...	·25 „
1·90 „ ...	1·94 „ ...	·12 „	2·60 „ ...	2·64 „ ...	·26 „
1·95 „ ...	1·99 „ ...	·13 „	2·65 „ ...	2·69 „ ...	·27 „
2·00 „ ...	2·04 „ ...	·14 „	2·70 „ ...	2·74 „ ...	·28 „
2·05 „ ...	2·09 „ ...	·15 „	2·75 „ ...	2·79 „	·29 „
2·10 „ ...	2·14 „ ...	·16 „	2·80 „ ...	2·84 „ ...	·30 „
2·15 „ ...	2·19 „ ...	·17 „	2·85 „ ...	2·89 „ ...	·31 „
2·20 „ ...	2·24 „ ...	·18 „	2·90 „ ...	2·94 „ ...	·32 „
2·25 „ ...	2·29 „ ...	·19 „	2·95 „ ...	2·99 „ ...	·33 „
2·30 „ ...	2·34 „ ...	·20 „			

The above progression was to continue so that 1 cent additional royalty would be required for each additional 5 cents increase in price. It will be noted that at 2·99 dols. per ton for iron ore, the royalty would amount to 33 cents, or 1s. 4½d. per ton.

The original owners of most of the Mesaba iron mines, so far as they had any ownership at all, up to a few years ago, were Michigan lumbermen, a number of whom have suddenly become very rich. These men have gone to work in a way that proved they had all their wits about them. They began by demanding small royalties, but they have increased their demands from time to time until the present average royalty is probably as high as the average of Great Britain. In some cases, the more recent royalties have been reduced on the condition that the minimum output is increased. Several cases could be cited where royalties were reduced from 30 to 25 cents per ton, on the condition that the minimum annual output was doubled. In times like the present this suits both parties. When depression comes, it may suit neither.

Coal Royalties.

Throughout the United States, it is the custom to charge royalties on coal when it is not worked by the owner of the freehold. The royalty varies according to the importance and accessibility of the field, but it rarely exceeds 20 cents (10d.) per ton. Mr. Lynch, president of the Frick Coke Company, informed me that the United States Steel Corporation debits their coal with a royalty charge of 8 cents (4d.) per ton, but he added that this was the actual cost to the corporation, that it was uncommonly low, that if the field was acquired to-day a much higher royalty would be charged, and that in the Connellsville region, the only important competitive concern is paying a royalty of 20 cents (10d.) on coal and 30 cents (15d.) on coke.

CHAPTER V.

The Natural Gas Supplies of the United States.

BESIDES their important and exceptionally cheap supplies of iron ore, coal, and coke, the United States possesses, scattered over a wide area in the principal manufacturing States, a large if not an almost inexhaustible supply of the remarkable product known as natural gas, the influence of which cannot properly be ignored in any consideration of the resources of the country.

This gas has come into very general use for manufacturing purposes since about the year 1880, first, I am informed, by the firm of Spang, Chalfant & Company, of Pittsburg, in rolling mills. New fields were found from time to time in Indiana, Ohio, Pennsylvania, and elsewhere, and the use of the gas rapidly increased, both for manufacturing and for domestic purposes.

When the Iron and Steel Institute visited Pittsburg in the autumn of 1890, natural gas was being generally used, and the visitors were afforded the opportunity of seeing an illumination by it on the Mononghahela River.

To-day, the combined capital of the companies engaged in the natural gas business in the Pittsburg district aggregates about 40,000,000 dols. They operate between 2,500 and 3,000 miles of pipe lines. They hold under lease 500,000 acres of land, on which are drilled from 1,200 to 1,500 wells, and are paying upwards of half a million dollars annually in rental and royalties to the farmers.

The average daily consumption of gas approximates 130,000,000 cubic feet, and in the winter time it is about 50 per cent. greater. Natural gas replaces daily through the summer about 7,000 tons of coal, and in the winter time nearly twice as much.

Prior to 1890, the supply of gas seemed so inexhaustible, and the devices for confining it so imperfect, that no effort at economy was practised in its use; but about that time there were evidences in some of the older fields that the supply of gas had commenced to fail, and for a time it was feared that the end of the natural gas industry was not distant.

Since then, more economic methods of consumption have been introduced, and at the same time the natural gas territory in Greene County, Pa., and in West Virginia, have been developed and made accessible, which have given to the gas industry a new lease of life.

Probably about one-third of the natural gas supply of the Pittsburg district is now being received from Armstrong County, and

the old fields contiguous to Pittsburg; another third is being brought from Greene County, the remainder being obtained from West Virginia. The latter fields are the most extensive and prolific gas fields yet discovered. The rock pressure of many of the wells is stated to exceed 1,000 lbs. to the square inch, and several of the wells show a volume of fully 25,000,000 ft. in 24 hours.

Two large companies are now bringing gas to Pittsburg from a distance of more than a hundred miles, and two or three more companies from points as far south as Greene County. The supply of gas from the older and more depleted fields is being augmented by the use of large pumping stations, which aggregate upwards of 4,000 horse-power, and are capable of passing 60,000,000 ft. of gas daily.

The high pressure of the wells of West Virginia and Greene County is said to be sufficient to furnish ample power for transporting the gas from those regions, the only limit to the amount of gas secured being due to the size of the line.

More than 40,000 families are being supplied from the lines of one company, and nearly one and a half billion feet are being furnished monthly to manufacturing consumers. The total amount of gas furnished by this company during the coldest days of last winter amounted to more than 100,000,000 ft. The company has two large lines through which it brings its gas from Armstrong County, one of which is 20 in. in diameter, and the other is composed of pipes 30, 24, and 10 in. in diameter. Each of these lines is equipped with pump stations, which have a capacity of upwards of 30,000,000 ft. per day.

The gas, from its southern fields, until 1899, reached Pittsburg through a 36-in. line, which was fed by two 16-in. lines, and these by one 20-in. line, which was supplied by one 16-in. line, extending 30 miles into West Virginia. This system has since been supplemented by the laying of a parallel line consisting of 12 miles of 36-in. pipe, nine miles of 20-in., an equal amount of 16-in. pipe, and eight miles of 10-in. pipe, which doubles the capacity of the system, and renders unlikely a shortage to domestic consumers even in the coldest weather.

It is said that either of these lines is able to transport 80 million feet of gas in 24 hours. It may be added that one company now has a 36-in. line extending more than 20 miles south of Pittsburg, made of steel plates, riveted and caulked. The cost of this pipe, and the labour in laying it, makes the line almost as expensive as an ordinary railroad, amounting to upwards of 50,000 dols. per mile.

The old fields from which the gas was drawn 15 years ago in great quantities, the surplus not needed being allowed to waste and burn in the open air, have been largely exhausted. Since then, however, with more economical appliances, with the wells properly tubed, so that the surplus gas not needed for consumption can be shut in the well, and with transportation lines clamped and jointed with high pressure couplings, the supply is better husbanded. It is said that the deep sand wells of high pressure in the southern fields already explored indicate supplies of gas sufficient to last for many years to come, and that the supply of gas now in sight is greater than at any other time in the history of the natural gas industry.

I asked several of the leading manufacturers in and about Pittsburg whether there was any material economy in the use of natural gas in place of bituminous coal. The reply was generally the same—namely, that there was not so much economy in the fuel, considered as such, as there was advantage in other directions, and especially in having gas always at hand, under perfect control; while its freedom from dust, soot, and, to a large extent, from smoke as well, the absence of ashes, and the getting rid of stoking, enabled savings to be made in labour and in wear and tear, apart from the obvious convenience of the different conditions stated. The economy in point of first cost would also be material did it not happen that Pittsburg has all along had, and still possesses, some of the cheapest fuel in the world.

In 1890, each ton of finished steel was estimated to cost 8s. 4d. for fuel in the neighbourhood of Pittsburg, in cases where the collieries were near to the works, and the cost of natural gas fuel was credited at about one-half of this figure. This estimate, however, does not appear to have taken into account the very considerable cost involved in piping the gas and the redemption of capital on so hazardous a form of investment.

The principal constituents of natural gas are marsh gas, 67%; hydrogen, 22%; ethylic anhydride, 5%; nitrogen, 3%; olifient gas, 1%; and oxygen, 8%.

The use of natural gas has not been attempted in the blast furnace, so far as I have learned, although it has been suggested, as well as the use of petroleum.* Whatever economy the American iron trade may derive from their abundant stores of this form of fuel must, therefore, be limited to its use in steel works, tube works, tinplate works, and kindred establishments, and, so far as my information goes, the difference in favour of natural gas is but trifling. This can more readily be understood when it is added that there are few cases in the United States where a ton of steel cannot be melted for less than 2s. outlay on fuel

* At South Chicago Works open-hearth furnaces are worked by oil, costing 40 to 45 cents per barrel of 50 gallons, the cost per ton of steel melted being about 1s. 8d. which is a penny or so under the cost of coal for the same operation.

SECTION III.

CHAPTER VI.

The Labour Conditions of the United States.

Rates of Wages.

SCATTERED throughout this Report, as well as those of my colleagues will be found a good many specific rates of wages for different grades of labour, and these, speaking generally, will probably afford a sufficient indication of the range of remuneration in the chief iron-producing centres. It would, of course, be easy to extend this information to a portentous length, but I do not deem it to be necessary.

It may, however, be expected that I should, in a separate consideration of the subject, give certain specific details as to the conditions that characterise American labour from this point of view. I cannot do this more effectively than by making certain excerpts from a statement submitted to the Wilson Tariff Committee in 1894, as to the then rates of wages in Great Britain and the United States, rates which continued to prevail over a large part of the period between 1892 and 1898, and which, therefore, may be regarded as fairly normal, although they have been exceeded during the last three years. The range is higher than in England by 40 per cent. for puddling, 35 per cent. for rolling, 40 per cent. for millwrights and blacksmiths, 50 per cent. for chief engineers, 50 per cent. for hoop mills $\frac{3}{4}$ wide, and 45 per cent. for $\frac{5}{8}$ wide, all per ton.

In the iron mines of Alabama and Tennessee, according to information given me by Mr. Baxter, the President of the Tennessee Coal and Iron Company, good men can make as much as 4 dols. per day, working with an assistant and taking a percentage of his earnings, as many of them do. Not a few of the negro miners are responsible contractors and earn very high wages. A feature of the Alabama mines is that the men are paid every day.

At one of the leading mechanical workshops in Philadelphia we found that it is quite a usual thing for one man to run three machines at one time; and in the case of boring mills, four machines to one man are not at all uncommon. In this particular establishment the men are paid as under:—

Machinists	27 to 32 cents per hour.
Fitters	30 to 32 „ „
Labourers	15 „ „

It is sometimes made a complaint in British works that there is too great a disparity between the low-paid and the high-paid labour, but that also appears to be a characteristic of American works. At Vandergrift, for example, I was informed by Mr. Pargny, the able manager, that the men employed in the galvanising department, mainly Poles and Hungarians, were paid an average of 16 cents (8d.) per hour, or from 1 dol. to 1¼ dols. per day, whereas the head rollers, working alongside, were paid 14 dols. a day, and the average wages of the rollers is 12 dols. per day of eight hours. The same sort of differences, but varying in degree, run all through American labour, according to the skill demanded.

The general tendency of American wages within recent years is thus referred to in the reports of the Industrial Commission now sitting in Washington :—" It does not seem to be the case that any reduction in wages, speaking generally, has followed their organisation (trusts), although in certain instances, as in that of travelling salesmen, the combinations have been able to dispense with the services of some workmen. Often since the combinations have been formed, wages have been increased. In other cases wages throughout the different branches of the industry have been made more nearly uniform than they were while the establishments were under different managements; and, generally, so far as one is able to learn, the process has been one rather of levelling up than of levelling down."

The average range of wages actually paid in the United Kingdom may be indicated by the following statement of averages paid at works in the leading districts for all labour employed, which I have obtained from British firms, as those of a normal period :—

District.	Character of Works.	Average per ann.
Lancashire	Iron and steel works ...	£68 0 0
Derbyshire	Blast furnaces, foundries, etc.	61 10 0
Yorkshire, West	Blast furnaces and steel works	70 0 0
South Wales	Steel works	79 0 0
Northamptonshire ...	Blast furnaces	64 0 0
Cumberland ...	Blast furnaces	70 0 0

These figures apply to a period preceding the recent boom. It may be interesting to add here that Mr. Andrew Carnegie some years ago claimed that the average wages of men in his employment at Homestead was over 3 dols. (12s. 6d.) per day, which, assuming 300 working days, would give an average of £187 10s. a year.

Piece Work.

In the United States, as in Great Britain, there are considerable differences of opinion and experience as to the particular system of remuneration which, taking all things into account, is most convenient and equitable to both parties. At the same time, I found in most of the works and shops visited that piece work is very general in all operations that call for a considerable amount of skill, and, indeed, wherever the work is above the level of unskilled labour. This is appreciated by the employer, because he knows thereby approximately what the work is likely to cost, and is not so liable to be "out" in his

estimates as if he had to depend on the uncertain quantity of varying efficiency and industry represented in day wages ; and to the workman because he can depend upon being remunerated according to the degree of his capacity and industry.

The views of the leading employers on the piece work system are thus expressed in forcible language by a well-known American employer in a recent address :—

" If on piece work a man, by skill and energy, increases his pay largely we think him entitled to such increase, for we economise fuel, interest, and other important items. It does not seem quite honourable, if he thus profits and we also, for us to cut away his profits, that we may gain much more ; nor do we believe it pays. In our industry repairs count largely, and a well-paid man will so care for machines as to minimise the need for repairs, because he loses by the time taken for such repairs ; he does not waste material, for often in our processes he may waste his own valuable time when he wastes material. We find also that justly-paid men save in the important item of imperfect work ; our men replace in their own time work that is bad, and pay for the material. Thus saving as we do in material, repairs, interest, fuel and other ways, we think justice to the workman demands that we shall not cut the piece work rate merely because he makes well thereby."

Agreements are made to a considerable extent between the Amalgamated Association of Iron, Steel and Tin Workers and their employers as to piece work wages rates based upon the sliding-scale system. This is the only trade in the United States in which sliding scales have been permanently introduced. As the prices of bar iron, steel, tinplate, etc., vary, the rates paid to different classes of workmen for producing a ton or other given quantity of the product vary in a definite ratio. Thus, by a recent agreement covering the manufacture of sheet steel, fixed rates for doing various classes of work were established on the basis of a price of 2½ cents per pound for certain classes of sheet steel. With each advance of one-tenth of a cent (equal to 4 per cent. on the base) wages were to go up 2 per cent., and for each decline of one-tenth of a cent they were reduced 2 per cent. Both employers and employés have usually seemed to be well satisfied with the working of the sliding-scale system, although the workmen insist upon a minimum below which wages shall not fall.

At some works in Philadelphia the men are paid by the hour, and it is stated on the employment sheet how much each man has to receive. The head of one establishment told me that he did not like piece work, because, he said, " it costs all I can get by the bonus system to keep the accounts straight in the factory. Under this system," he added, " we have got to see that the man is honest by checking his work every night, whereas my system provides that every man is his own timekeeper."

At some of the leading American engineering works, including those of William Sellers & Company, of Philadelphia, the men are paid both by piece and by hour—that is to say, the work to which they are put is given to them at piece work prices, but the arrangement is

an hourly rate, so that on the completion of any particular piece of work, the man is paid the balance due to him over the wages received *pro rata* according to the wages agreed upon per hour.

Although most of the men at the Baldwin Locomotive Works are generally on piece, yet a considerable number are in receipt of fixed daily wages. All the men employed in the works have a limit of wages fixed by the firm. Some men make as much as 4 dols. (16s. 8d.) per day, but, whatever his wages may be, a man knows that it will not fall below the minimum adopted at the time, and that if he is deserving of a higher rate, he will be pretty sure to get it. In giving out their work, the Baldwin Company place the contracts for the building of locomotives in the hands of leading men, and a good many are working on sub-contracts.

A recent modification of the piece work system, which has now become very general, is called the "premium plan" of paying for labour. Its object, like that of piece work, is to encourage individual workmen to increased output, but it differs from piece work, inasmuch as the workman's reward can never be cut down below a certain fixed rate, and for that reason it is more acceptable to those union men who pronounce against piece work. An average of the time taken in certain operations is struck. This average is called the time limit. If the workman takes the full time limit, he receives simply the fixed rate of wages; but if by industry or ingenuity he accomplishes the work in less time, he is paid a 50 per cent. premium on every hour or part of an hour that he has saved. The saving, in fact, is divided between the employer and the employé, so that both gain something by the arrangement. There is no temptation, on the one hand, to cut down the rate, and, on the other hand, the workman can always be sure of his full pay, and a premium for extra effort. The system guarantees full current wages to poor workmen, benefits to mediocre, and secures for the skilled considerably more than they could possibly earn under the time arrangement. Generally, under this system, experience has shown that there is a largely increased output for the same labour-cost, an increase in the workmen's wages of from 10 to 40 per cent., the necessary maintenance of machines in the highest state of efficiency, a greatly-increased interest of the men in their work, a field for the choice of the best workmen, and a better understanding between the men and their foremen.

In the United States, most employers with whom I have had the opportunity of conversing, have expressed a preference for the piece work system, and in some cases no other would be tolerated.

At Altoona Works, the Pennsylvania Railroad Company recently tested the comparative value of the two systems of day work and piece work with remarkable results, which seem to be pretty conclusive.

It is stated that, before the introduction of piece work, 50 new locomotives per annum represented the capacity of the Altoona shops. Since that change, the output—with substantially the same tools and appliances—has doubled. The cost by day work in the erecting shops of what are known as Class I. engines was 290 dols. The same amount of work, on engines of the same general class, but about 15

tons heavier, now costs 95·75 dols., and is done in one-half the time. . . . . By day work it took three days to build a box car. This work is now done in 15 hours. The pipe work on a locomotive formerly cost 137 dols., and now costs 32 dols. Finally, while the output has been doubled, and the cost of labour reduced one-half, wages have been raised more than 25 per cent. under the new system.*

The Contract System.

The so-called contract system is very general in the rolling mills of the United States. Under this system, each boss, or contractor, hires, pays and discharges his own men. The principal contractor in a large number of cases is the head roller, who contracts directly with the owners, and who receives the whole price of the work finished by himself and his gang, and distributes it among the men employed under him. There are, however, notable exceptions to this system—among others that of the Vandergrift Works of the American Sheet Steel Company, who pay every one of their men direct. The contract system is founded on a scale, or set of ton-prices for finished rolling-mill products, agreed upon between the owners of the mills and the Amalgamated Society of Iron and Steel Workers, which is usually reconsidered once in every twelvemonth. As a rule, contractors do not pay their men piece rates, but sub-contractors are not uncommon.

The contract system is also still employed to a considerable extent in machine shops and factories, although less so than formerly. A recent writer has declared that the system in such works has "now fallen into disfavour, and either has been, or is soon likely to be, displaced, by fixed-pay foremen in charge of piece-rate workmen." Many owners of works in the United States have set their faces so completely against the contract system that in the opinion of some of the most experienced authorities, the contractor, as hitherto established, is likely, before long, to entirely disappear.

Intensity of American Labour.

There appears to be a pretty general impression that the characteristics which differentiate American labour, so-called, from that of other countries, are to a large extent of recent origin. A critical and comprehensive analysis of the phenomena of American progress would, however, probably show that they are almost as old as the country itself. They are, first of all, a function of the greater industry, ambition, and resourcefulness of the people that emigrate. Such people, as a rule, are naturally and inevitably disposed to cut themselves adrift from the hide-bound traditions and habits of the country where they have not realised their ideal of life, in order that they may reach a higher standard of attainment and of comfort. But this cannot be done without much effort, great readiness to meet emergencies, and a general faculty for making opportunities.

"Sam Slick" declared the United States to be "a land of hard work, with two kinds of slaves, the niggers and the white slaves. Neither rich nor poor, high nor low, with us eat the bread of

* *American Engineer and Railroad Journal* for 1900.

idleness. . . . . An idle fellow who runs away to us is clapt into harness before he knows where he bees, and is made to work; like a horse that refuses to draw, he is put into a team-boat; he finds someone afore him and others behind him. He must either draw or be dragged to death." This, which was true of American conditions when Judge Haliburton wrote his well-known work, more than 60 years ago, is equally applicable to the American to-day. The British workman, transplanted on American soil, becomes a different man. He finds himself at once drawn into a strong current of pushful, active, virile and aggressive life, and he must go with the stream.

The American workman is generally very nimble-minded, versatile, alert, and intelligent, quick to pick up new ideas, and equally ready to apply them. He rejoices in the fact that he has direct access to his employer, and that both his employer and his "gaffer" are ready at all times to discuss matters of concern in a friendly and conciliatory spirit. An American friend recently said to me, in language perhaps more forcible than choice, that in England the employer expects too much consideration from his workman, and is far too stand-offish, if he does not actually expect him to "lick his boots."

One of the most important questions that can occupy the minds of both employers and employed in this country is that of whether it is possible to bring American and British labour to the same level of efficiency. To do this, the American labour would have to be levelled down, or the British labour would have to be levelled up, to the same capacity for output, or rather to the same volume of daily work, whether that volume be founded on superior capacity, or superior industry, or on these and other qualities combined.

That much is possible in this direction, by better organisation, has been demonstrated by a notable example, the details of which have recently been published. It will be remembered that some months ago *The Times* newspaper printed a series of articles on "The Crisis in British Industry," one of the first of which spoke of the decay of the productive capacity of British bricklayers, who, instead of being content to lay 1,000 bricks per day, or more, which was alleged to have been done formerly, were now limiting themselves to 400 bricks per day, more or less. This situation led to a considerable amount of discussion in *The Times* and other journals, and elicited some interesting details as to a recent experience of the Westinghouse Company, which would seem to show that the British workman is capable of doing quite as well as his American *confrère*, and is ready to do it if he is properly handled.

The Westinghouse Company decided to establish works for the manufacture of electrical apparatus at Trafford Park, Manchester. When the work was begun in the spring of 1901 it was estimated by British builders that the building operations alone—quite apart from the installation of machinery—would occupy several years. The Westinghouse Company, however, anxious to get to work quickly, engaged Mr. James C. Stewart, a well-known American contractor, as building manager, and he, with half a dozen American assistants, and 3,758 British workmen, established an average of 1,800 bricks per man in a nine-hour day, with a maximum of 2,500 bricks per day for the

plainest work. And how was this done? The published reports state that Mr. Stewart simply got rid of men who were not up to the work. During the third week of operations the average had risen to 900 bricks per man per day, and by the continuous process of weeding out the idle and useless the standard of 1,800 bricks was approached, despite some interference on the part of the trade unions.

This story suggests the question whether it would not be possible to make much more of the average British workman if he were differently handled. It is at least worth the while of British employers and managers to ask themselves whether, in order to secure the American standard, they have done all that is necessary in giving the workmen American conditions.

While at Philadelphia, I called on Mr. Newton, of the well-known Newton Machine Works, and had an interesting talk with him on the two subjects of the economy of production due to improved machine tools, and of the characteristics of British *versus* American labour. On both I found that Mr. Newton was a close observer, and a capable economist.

Speaking of the different characteristics of workmen, Mr. Newton held the opinion that in Great Britain the ordinary workman was too much in the habit of taking stimulants at his meals. At his works, he said, not more than 5 per cent. of the workers took beer at their meals, but many of them drank milk, which is consumed in large quantities.

In England, Mr. Newton has closely watched the operations of workmen when he had opportunity. He expressed his great surprise to find in London, from personal observation, that bricklayers only laid at the rate of about 400 bricks per day. In the United States, the same man would lay from 1,500 to 2,000 in nine hours, for which, at the present time, they are paid 4 dols. 20 cents (17s. 6d). In Philadelphia a carpenter earns 3½ dols. (14s. 7d.) per day. But both of these cases are excelled by that of the skilled men in machine tool works. In Mr. Newton's own factory, the best men are paid 55 cents (2s. 3½d.) per hour, and the lowest wage paid to a skilled mechanic is 43 cents (1s. 9½d.) per hour, mainly on piece.

The average American workman, says Mr. Newton, is not more fond of work than the worker in other countries, but he is affected by his environment, and he likes to take home as much money as possible at the week end. In other countries the American workman does not always do better than his fellow. Two cases in point were cited by Mr. Newton. Some years ago a large engineering establishment at Zurich brought over a number of American workmen to Switzerland, thinking thereby to secure American conditions. The firm of L. Loewe, of Berlin, did the same. In both cases the results did not answer expectations.

The Morale of American Workmen.

Under this head, I would venture to class three qualities which are demonstrable, both by observation and by statistics—the first, the general sobriety and steadiness of manual workers generally; the second, the regularity with which they stick to their employment;

and the third their general contentment, as a result of the prosperity and comparative freedom from care largely due to the two first-named characteristics, but also founded on the workman's general economic situation.

In all the cases where I made inquiries—and they were numerous—I was informed that the workmen, speaking generally, were not much addicted to alcohol, and that a large proportion of them are teetotalers, and this fact is supported both by official records as to *per capita* consumption of alcohol, and by an inspection of the conditions under which the majority of the workmen live.

For averages of five to ten years, the *per capita* consumption of wine, malt liquor, and spirits in Great Britain, France, Germany, and the United States, in gallons per head of population has been as follows, as shown in returns prepared by our own Board of Trade :—

	Wine.	Beer.	Spirits.
United Kingdom	·39	31·7	1·12
France	24·04	6·2	2·02
Germany	1·45	27·5	1·94
United States	·33	13·3	1·06

This would give for the four countries named a *per capita* consumption of alcoholic beverages as follows :—

United Kingdom	33·21 gals.
France	32·26 „
Germany	30·89 „
United States	14·69 „

These figures seem to show that the average British workman takes about 130 per cent. more alcohol than his American compeer.

It is one of the best known characteristics of the American people as a whole that they are uncommonly temperate, and this is as much the case with the working men as with other classes of the community. The average working man in the United States takes milk, or tea, or cocoa, or coffee, rather than beer. At many of the principal works beer is not allowed on the premises under any conditions. This gives a great advantage to both employers and employed—to the former because it ensures elimination of the worship of Saint Monday, and the irregularity in the employment of machinery and plant which that worship involves ; and to the latter because it guarantees that he shall not only be more fit for his work on the first of the week, but can depend on taking home a larger wage at its close.

The regularity of the typical American workman is a matter of the most common knowledge and repute. The amount of lost time is remarkably small, whether in mining, in iron and steel works, or in engineering shops. Not 5 per cent. of the men employed are late on a Monday, in some cases of which I obtained particulars, and promptness to leave and to return appears to be their characteristic at all the works I visited.

Opportunities.

In the United States, workmen are generally content because great opportunities are open to the majority of them, as well as to the

employer and the manager. Take the case of a sheet mill in proof of this fact. The rollers in sheet mills are paid among the highest wages received by working men, properly so called. To attain that position is commonly the ambition of a man who cannot well aspire to look higher. It means a transition from a dollar a day to 12 or 14 dollars. And yet I was informed by Mr. Pargny that at Vandergrift they have taken comparatively raw hands, employed as scrap boys, heaters, troughers, or catchers, and made rollers of them in about six months, carrying them in that interval up through the intermediate grade of underhand, where they had opportunities of watching and learning the methods of rolling. A remarkable instance of what is possible in adapting American labour in this way was recently furnished by the case of the Hyde Park Mill during the strike in the autumn of 1901. The old hands had come out, and, as trade was good, it was resolved that the works should be continued with green hands, aided by one or two skilled men who remained loyal. The five mills thus manned were started on the 3rd of August, and up to the date of my visit, near the end of October, they had not, Mr. Pargny informed me, lost a single turn.

At a meeting which we had with Mr. C. M. Schwab, he informed us that in his opinion the two greatest difficulties that we had to contend with in Great Britain were—first, the attitude of labour; and next, the exceptionally high cost of transport. With these drawbacks out of the way, he implied that there might be a prospect of our still holding our own. But he regarded the question of labour as fundamental, and in discussing the attitude of trade unions in the matter of skilled labour, he expressed the view that a great deal too much was made of this point. In proof of this, he intimated that experience had satisfied him that he could take a "green" hand—say a fairly intelligent agricultural labourer—and make a steel melter of him in six or eight weeks.

These are cases that are actually occurring from day to day throughout the iron and steel works of the United States. The fact that they are so occurring, and are liable to occur again, stimulates the workmen to seek for improvement both in knowledge and in position. There is no—or at least very little—obstacle thrown in the way of such advances by trade unionism. It is generally a matter for the workman himself, and for him alone. Indeed, many Englishmen have noted that the American practice of advancing workmen and young men, on what in this country would be regarded as insufficient experience and knowledge of *technique*, is dangerously near to the permissible margin of safety.* Possibly accidents and mistakes sometimes result from this cause, but it is fairly debatable whether in the United States these are much more frequent or more serious than in other countries, where men are often deemed to be unfit for responsibility until they have grey hairs.

* A case that happened to a friend of my own is one of the most notable I have heard of. He was only 20 years of age, when, without any previous experience, he was despatched by his employers to inspect, at the site and during the course of construction, the steel used in a very important bridge then being erected. Being an Englishman, with English traditions and ideas, he was timid about undertaking the job, although he had acquired a certain knowledge of the properties and treatment of metals. In the long run, he accepted the job, and carried it out satisfactorily.

American workmen have better cause to be contented, not only because they can generally secure full employment at exceptionally high wages, but also because they have now the means to live very nearly as cheaply as in Great Britain. I made certain inquiries both in the Eastern and the Southern States as to the cost of living, and the information placed at my disposal satisfied me that the average American workman, in most of the essentials of life, with the single exception of house rent, can live, *mutatis mutandis*, as cheaply as he can in the old country. Clothes have hitherto been dearer in the United States, but even in the matter of clothing the American workman is not now much behind. It is certain that in workmen's restaurants generally he can do as well for the money expended as he can in England, with but few exceptions, while beef and fruit, which are the staples, are usually cheaper. To test the general economic situation in this regard, I dined at a popular restaurant, just off Fifth Avenue, and I got a five-course dinner for less than 2s.—quite as good a dinner as I could probably have commanded in England at the same price. Generally, strictly workmen's restaurants are equally reasonable.

Influence of Heterogeneous Population.

In one respect the American mine-owners and manufacturers enjoy an advantage which is almost quite unique, and is a result of the extraordinary conditions under which the country has been populated, and labour has been applied and organised. Throughout the United States there is a wonderful variety of nationalities, who have little in common, except the fact that they are working for wages. They are not of the same race, they do not speak the same language, they have not been trained amid the same social and economic surroundings, they have not inherited the same traditions. Little wonder, then, that when brought together in the great alembic of American industries they prove to be almost as immiscible as oil and water.

It may be true that in the long run the social alchemy of the United States will fuse these different materials into one homogeneous mass. A long time, however, must elapse before this end is attained. A large part of the emigrants that make up the population of the United States to-day, are uneducated, superstitious, shiftless, indolent, and unenterprising. The Americans believe that with democracy as a social solvent, the common school as a crystallizing agent, and intelligent freedom as the chief laboratory product, these characteristics can be radically changed—and possibly they can be, but not yet. In the eight years ended with 1894, about half a million of emigrants landed annually on American shores. Since then, owing to the restrictions imposed by the United States Government, the number has fallen to less than 300,000 a year. Nevertheless, during the last fifteen years some seven million emigrants have been carried to the United States from every country in Europe, including Slavs, Czechs, H[illegible], [illegible] Swedes, Italians and Irish, not to speak of minor nationalities.

The effect of this process of blending races is [illegible] the long run beneficial to the character of the community, because the [illegible] emigrant is, in the majority of cases, a more capable and [illegible] man than the majority of his fellow-countrymen [illegible]

behind. But meanwhile the main concern of the emigrant is to get employment, almost at any cost, and the meanest and most common of labour in the United States, by enabling him to draw at least a dollar, and in the majority of cases a dollar and a half a day, places him in a position which is almost affluence itself compared with the conditions to which he has been accustomed in his own country. He is not, therefore, *primâ facie* inclined to join in any movements or organisations, such as trade unionism, which would possibly make his circumstances worse rather than better, even if he had other good reasons for joining his fellow-labourers, but not his fellow-countrymen, in such matters.

But he has other reasons. The jealousy and envy that are common to one race or class, in competition with another, are nowhere more clearly shown than in the United States. The solidarity of action and of interests that would be likely to prevail were the ranks of labour of one nationality, is thus made practically impossible. Trade unionism, with its laws, its aspirations, and its influences, is thus kept in constant check. It becomes comparatively easy under such circumstances for the employers to have their own way, and when strikes are threatened or declared, the ranks of labour do not close up as they would do in Great Britain. Indeed, the mixture of nationalities is the greatest protection against trade union exactions that employers can enjoy. Almost every American employer with whom I had the opportunity of discussing the subject admitted this to be the case, and spoke with the utmost candour of the advantages over British conditions that were thereby afforded to the United States. Labour in that country is not nearly so aggressive as it is in our own. Most of the labour organisations founded in the United States, from the time of the Molly Maguires, down through the Knights of Labour and other organised bodies of workmen, have fallen to pieces from the lack of cohesion and one-ness of ideas and interests due to this cause. Hence workmen are generally ready to make individual bargains with the individual employer; each workman considers only himself, and need not heed the effect of his isolated contract on the mass of his fellow-workers. Hence, also, the readiness of the typical American workman to fall in with any proposals made by the employer as to how and when and with whom he shall work, and the almost total absence of those restrictions on individual liberty which are so prominent a feature of labour conditions in British industries. The situation as thus described, is not, however, wholly dependent on differences of race, tradition and habit. The typical American mechanic has been described by a capable and shrewd observer,* as one who "lives chiefly to save labour, and that labour appreciates the value to itself of the mechanic's function," while "in England, those characteristics are replaced by the ancient wages, by the schemes fettered by trade society rules, and by operatives who dislike all labour-saving appliances because they make work scarce."

With reference to the quality of mining labour, an interesting summary of the characteristics of the different nationalities employed

* D. Pidgeon in *Old World Questions, and New World Answers*, p. 281.

in the Lake Superior iron ore industry, was given in the recent Annual Report of the Commissioner of Labour of Minnesota, which stated that of 8,000 miners in the State, 40 per cent. are Fins, the same Austro-Huns, 8 per cent. Italians, and the remaining 12 per cent. American, German, Scotch, Swedish and Welsh. The Austrians are stated to be the least desirable of all. The Fins are said to make excellent citizens. The Welshmen and Americans are, of course, the best miners, but most of them go to fields where they will not compete with unskilled labour that has been accustomed to a wage of a few cents a day, and the few that remain have positions of reliability and trust.

In some cases the proportion of native Americans employed in the iron industry is larger than in others, much depending on locality. At Vandergrift, for example, 90 per cent. of the workmen were declared to be native Americans, the remainder being generally Swedes, employed as machinists, and Poles and Hungarians, employed in galvanising and pickling, which is a description of labour for which the native American has but little fancy.

Extent and Growth of Population.

The Census Report on the population of the United States by sex, nativity and colour in 1900, shows that the males numbered 39,059,242, or 51·2 per cent. of the population. The increase of 13,233,631 in total population since 1890 is made up of 6,744,179 males and 6,489,452 females, an increase of 20·9 of males and 21·1 of females. The foreign-born element has increased by 12·4 per cent. and the native-born population 22·5 per cent. Since 1890, as to colour and race, the population in 1900 comprised 66,990,802 white persons and 9,312,583 coloured persons, the latter comprising 8,840,785 persons of negro descent. The coloured element as a whole shows an increase of 17·8 per cent. since 1890.

From these figures two inferences appear to be justified—the first that the foreign-born population is relatively decreasing, so that there is a probability of increased homogeneity of labour in the future; and the second that, whether for good or for evil, the negro population continues to multiply, and must remain an important factor in labour questions in the time to come.

Pension and Relief Funds.

In most of the leading works of the United States, the workmen have established funds for the purpose of providing pensions in old age, medical attendance in case of sickness, and relief in case of want of employment or other necessities. Some of the principal schemes of this kind brought under my notice were those of the Carnegie Company, the Midvale Company, and the Pennsylvania Steel Company. These are not only typical of the best of their kind, but probably actually are the best. Hence I have published in the Appendix the rules and conditions of two of them—the Midvale and the Pennsylvania schemes.

The Pennsylvania Railroad Pension Department was only inaugurated on the 1st of January, 1900. The year 1900 being the first of its existence, naturally brought before the board of officers in charge of the

department many vital questions for discussion and decision, involving points bearing upon the regulations of the department, and features tending to such improvements as were made necessary by practical experience, in addition to disposing of the regular routine of business.

In accordance with the provision made under the regulations, a plan was adopted for the appointment monthly of medical examiners of the company's Relief Fund, to serve as boards of physicians of the Pension Fund, with the duty assigned them of making physical examinations of such employés between 65 and 69 years of age who had been 30 or more years in the service, and who were incapacitated for the performance of further active service, and who either made personal request for retirement, or were recommended therefor by their employing officers.

There was authorised to be paid in pension allowances during the year, the sum of 244,019 dols., which expenditure was borne entirely by the associated companies, in addition to the cost of operation of the department.

The retirements during the year numbered 1,292, of whom 89 per cent., or 1,149, were 70 years of age or over, and 11 per cent., or 143, between 65 and 69 years old. Of the latter, 83 were retired at their own request on the recommendation of their employing officers, the remainder, 60 in number, purely upon the recommendation of their employing officers. One hundred and two pensioners died during the year, 95 of whom were of the 70-year or over class, and seven of the 65 to 69-year class.

The employés who have been retired from active service and are receiving the benefits provided by the regulations of the department, have indicated their gratification and pleasure by marked expressions of appreciation and evidences of universal satisfaction. The popularity of the department is widespread, not only among those who are the recipients of its favours, but also among the many who, in expectation of long years of life, hope to realise in their declining days the fruits of so worthy an institution, fortified in its generosity by the financial ability of so strong a corporation.

The pension allowances granted by the Pension Department are direct allowances made by the companies associated in the Pension Department, no portion of which is made up of contributions to any fund, or in any way, by the employés. There is no accumulated fund in existence, and the allowances are made as the result of an agreement by each of the companies associated in the Pension Department, by which their boards of directors, with the approval of the stockholders, consented to expend a certain fixed sum of money per year for the payment of pensions and the expenses of conducting that department. The pension allowances are charged out in the expenses of the different companies in the same manner as the wages of the employés were charged out prior to their being relieved from active service, and in that way become operating expenses of the companies.

The Carnegie Company's Pension Fund is founded on a trust gift of four million dollars made by Mr. Andrew Carnegie on his retirement from the firm in 1901. The donation was attended by the provision that the income from this gift should be employed to give relief to disabled

wage-earners on the Carnegie Company's plants, and for pensioning men who had been worn out in the service. As a trust fund it is not subject to any claims against the company which may be asserted or established by suit based on accident or death, and it is not dispensed in place of such relief as the company have been in the habit of providing where called for.

In many instances the workmen provide for cases of accident by contributions to the local hospitals, and in many cases the employers contribute equal amounts. One instance brought to my notice is that of J. H. Williams & Company, of Brooklyn, who, with their men, make the largest contributions to hospital work of any factory in the city. Here, also, as in many other cases, the men carry on a mutual aid society, which makes weekly allowances to the sick, immediate cash payments in case of death, and employs a physician, whose business it is to give medical attendance and medicine without charge.

The Apprentice System.

In a number of the leading American works, the principals attach importance to binding, as apprentices or otherwise, lads and young men who have had the advantage of a first-class education, and hence in many establishments which I visited I found that the college graduate in a subordinate position was by no means a *rara avis*. Indeed, in some cases, as at the works of the Midvale Steel Company, at Philadelphia, my attention was specially called to the unusually large number of college graduates that were employed on the premises in various positions. In other cases, as at the works of the Baldwin Locomotive Company, and of William Sellers & Company, it is quite a usual thing to start a college graduate on sufficient pay to defray the cost of his board and lodging, and so much importance is attached to having well educated workmen that in both of these cases night schools are carried on, for the benefit of young men or lads whose scholastic training has left something to be desired, and who are encouraged by various means to improve it. In such cases the foreman of a particular group of employés is charged with the duty of keeping an eye on the apprentice out of doors, as well as in the shops. If the foreman finds that the youngster is less diligent and regular in his studies than he should be, or that he has a tendency to loafing and looseness, the fact is made known, and promotion is affected thereby. In these and other ways, large firms like the Baldwin concern take infinite pains to get together a permanently steady, capable and contented class of workmen, and to a large extent they appear to be successful in their efforts.

In conversation with Mr. Vauclain, one of the partners in the Baldwin Locomotive Works, and the inventor of the well-known locomotive that bears his name, he told me that nearly 20 per cent. of the total hands employed at these works are apprentices. There is a strong desire on the part of the youth of Philadelphia to enter the Baldwin Works. Many young men get permission to enter without being indentured, on the chance of securing their indentures when they have been there for a time. The present form of indenture has been in operation since the beginning of 1901. In the Appendix will

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be found a circular on the apprenticeship system of the Baldwin Works, which gives details of the three classes into which the apprentices are divided, and shows that the rate of remuneration paid varies from 5 cents per hour for the first year, and 7 cents per hour for the second year, to apprentices of the first class, up to 13 cents per hour for the first year, and 16 cents per hour for the second year to apprentices of the third class. The last named are over twenty-one years of age, and graduates of colleges, etc., and not a few are glad to take advantage of the facilities thus provided at a rate of remuneration that enables them to procure a livelihood from the outset of their apprenticeship. At the same time, as the owners of the Baldwin Locomotive Works attach much importance to a sound and sufficient education, they provide facilities to the apprentices in the first and second classes to improve their general, and especially their technical, knowledge by night and other schools. There are four or five different institutes in Philadelphia that specially lay out their curriculum for such young men, and especially in respect of such subjects as geometry, algebra, etc. The same conditions hold good in other industrial districts.

A Typical Labour Agreement.

The following is a typical agreement of the kind that is now made between employers and employed under up-to-date conditions in leading industrial centres :—

" 1. That, beginning with July 25, 1901, the minimum wages for moulders in the city of St. Louis shall be as follows : For floor moulders, 2·85 dols. per day of 10 hours, and for bench moulders, 2·65 dols. per day of 10 hours.

" 2. That prices to be paid for piece work shall be fixed by mutual agreement between employer and the workman or workmen who perform the work. Such prices shall allow a journeyman moulder to earn at least the minimum wages for the class to which he belongs.

" 3. That all overtime, except in cases of accident or causes beyond control, shall be paid for at the rate of time and one-half, with double time for Sundays and the following legal holidays : Fourth of July, Labour Day, Thanksgiving Day and Christmas. Overtime exceeding 30 minutes, in cases of accident or causes beyond control, shall be paid for at the single time rate, provided, however, that in order to draw overtime the moulders must be willing to do additional work at moulding for a period corresponding to such overtime.

"4. That this agreement shall remain in force till July 1, 1902, and that a conference of the parties hereto shall be held on or about June 1, 1902, to arrange for the modification or extension of the same.

" 5. That during the life of this agreement no strike shall be ordered or sanctioned by the union, nor any lock-out ordered or sanctioned by the Association of Employers in the shop of any member, for any reason whatever, until the matter in dispute has been submitted to a committee of investigation or arbitration, to be composed of three members to be appointed by the association and three members to be appointed by the men. The decision of a majority of said committee shall be rendered within five days from the date upon which the question in dispute shall have been submitted to it, and shall be con-

sidered final, in so far as the future working of the respective organisations is concerned."

Strikes and Lock-outs.

Within the last three years the United States have witnessed three of the most important strikes that have ever taken place in its industrial history; the first being the strike of anthracite coal miners in Pennsylvania in 1900; the second, the strike of the machinists in various sections of the country in 1901; and the third, the great strike of iron and steel workers in the autumn of the latter year.

These three disputes afford the opportunity of saying something as to the general conditions of labour in the industries in which they occurred, and have so happened in relation to similar disputes in our own country as to enable useful comparisons to be made that practically illustrate the conditions of to-day.

The Anthracite Coal Miners' Strike.—This important strike, which took place in September of 1900, involved the closing of about 210 anthracite mines, and laid idle 142,500 hands, including those who were unable to continue at their employment, although not among the strikers.

The miners' grievances were stated to be—first, low prices for mining the coal by the ton, carload, and yard; second, the dockage system, which allowed the miner to be paid only for good coal produced, was declared to be robbing him of a large proportion of his labour; third, the practice on the part of the employers of demanding more than 2,240 lbs. to the ton, to enforce which the trucks loaded by the miners, which were supposed to hold just one ton, were greatly increased in size, many of them holding from 3,000 to 3,800 lbs., without any corresponding increase in payment; fourth, the high price charged for powder and the accessories necessary to the miner; fifth, the lack of uniformity in wages paid for labour in various districts; sixth, the sliding scale in force in the Lehigh and Schuylkill regions, including the Philadelphia and Reading Railroad mines at Shamokin; seventh, the price of living having considerably increased and the sliding scale having in some cases reduced the men's wages by 8 per cent.; eighth, failure on the part of the majority of the companies to comply with the State law, which provides that employés shall be paid semi-monthly in cash; ninth, the company store system, together with the compulsory doctor's fee; tenth, the system upon which the company store was worked compelled the employés of the companies to purchase all necessaries of life from the companies' stores; eleventh, failure to comply with this requirement was sufficient ground for a man's discharge; twelfth, owing to the excessive charges made under this system, there were instances where miners hardly ever received any cash payment, being always in debt to the company store; thirteenth, while it is true that this was sometimes due to extravagance on the part of the miner, it was naturally the policy of the operators to keep the men as much in their power as possible.

As a result of the strike the miners got an advance in wages of 10 per cent., and a promise on the part of the employers to meet committees of the men to adjust local grievances.

The Machinists' Strike.—In the case of the machinists' strike, in March of 1901, a form of "agreement" between the employers and the various lodges of the International Association of Machinists was drafted and presented to the owners of all union machine shops for their signature. The text of the "agreement" follows:—

1. *Machinists.*—A machinist is classified as a competent general workman, competent floor hand, competent lathe hand, competent vice hand, competent planer hand, competent shaper hand, competent milling machine hand, competent slotting machine hand, competent die sinker, competent boring mill hand, competent tool maker, and competent linotype hand.

2. *Hours.*—Nine hours shall constitute a day's work on and after May 20, 1901.

(Note: This arrangement of hours is not to interfere in any way with shops where a less number of hours per day is already in operation.)

3. *Overtime.*—All overtime up to 12 o'clock midnight shall be paid for at the rate of not less than time and one-half time, and all overtime after 12 o'clock midnight, Sundays and legal holidays, shall be paid for at the rate of not less than double time.

(Note: The foregoing rates are not to interfere in any way with existing conditions—that is, where higher rates than above are paid no reduction shall take place.)

4. *Night Gangs.*—All machinists employed on night gangs or shifts shall receive overtime in accordance with Section 3, for all hours worked over 54 per week.

5. *Apprentices.*—There may be one apprentice for the shop, and in addition not more than one apprentice to every five machinists. It is understood that in shops where the ratio is more than the above, no change shall take place until the ratio has reduced itself to the proper number by lapse, or by expiration of existing contracts.

6. *Wages.*—An increase of 12½ per cent. over the present rates is hereby granted, to take effect May 20, 1901.

7. *Grievances.*—In the case of a grievance arising, the above company agrees to receive a committee of their machinists to investigate and, if possible, adjust the same. If no adjustment is reached the case shall be referred to the above company and the representatives of the International Association of Machinists. If no satisfactory settlement can then be agreed upon, the whole subject-matter shall be submitted to a board of arbitration consisting of five persons, two to be selected by the above company, two by the above lodge of the International Association of Machinists, and the four to choose a fifth arbiter, and the decision reached by this board is to be binding on both parties to this agreement.

A prominent machinery manufacturer in Chicago, in June of 1901, made the following statement to the Press concerning the strike of machinists then pending:—

"The machinists demanded 12½ per cent. increase in the city of Chicago. We offered 5 per cent. at the last conference. At the first conference they were offered 6¼ per cent. Both propositions they refused and went out on strike. Incidentally the strike involves the question of freedom of shop management. To accede to the

demands of the union would mean practically placing each shop at the mercy of the International Association of Machinists. This would result in the extinction of the 'handy' men, the limitation of apprentices, the limitation of output, and shop rules and regulations hostile to the success of any manufacturing business. The growing disposition to interfere with shop management has alarmed the manufacturers throughout the country, who are not primarily opposed to liberal wages, but who see in the growth of the unions a menace to all manufacturing prosperity in this country. The average American manufacturer is proud of the wages paid in this country, and does not entertain the idea that American wages should be on a parallel with foreign wages. The American manufacturer believes that by superior shop management he can more than make up for the difference in the wage paid in this country as compared with that paid in Europe.

"Unionism has resulted in an apparent advance of wages now and then, but the showing is purely fictitious. With the constant menace of a strike, and collective demands for higher wages, the manufacturer in many instances has been obliged to adjust his wages to meet the conditions, well knowing that whatever individual rises he may have made on account of merit, he may still be subjected to a collective and arbitrary demand for further amounts. If unionism would keep its hands off the shops of America, and leave every mechanic to develop his efficiency unhampered by the dictates of his union, the wage would immediately respond to individual merit as it always has done. The lowest class of mechanic may have been helped to a higher wage through his union, but the best mechanic has been correspondingly robbed of his independence. The manufacturer hopes to resist this levelling process of unionism and restore the independence and manhood of the American mechanic."

On the lines here laid down, the issue between the International Association of Machinists and the National Metal Trades Association, as representing the engineering employers of the United States, was fought out. The strike followed on the refusal of the employers to meet demands made by the machinists in January, 1900, at which time their union was stated to be nearly 35,000 strong. The strike lasted for several months, and could not be said to have come to any formal close. While in some cases employers made concessions to the machinists, in the great majority of the works they gained nothing by the strike, and it could hardly be affirmed that it has to-day helped them to a more satisfactory position from a labour point of view.

The Iron Workers' Strike.—The strike which was undertaken by the Amalgamated Association in the summer of 1901 made it clear that the single control of the United States Steel Corporation had been of great advantage in meeting the combination of the workmen by united action on the part of the employers. It is not easy for a trade union to resist the action of an organisation with a stock capitalisation of 1,100 million dollars, and a debt of 304 millions, this being the largest capitalisation that has ever taken place in the history of industrial enterprise.

The strike of steel workers, which took place in the summer of 1901, and lasted for nearly two months in some localities, was one of the most abortive that has ever taken place on American soil. Virtually it was resolved on for the more general recognition of the union, although ostensibly also for other purposes. In the end the strikers had to come to a settlement on the basis of the *status quo*, and their official organ thus dealt with the arrangement :—

"The causes that led up to this unsatisfactory settlement were the overwhelming odds that the association had to battle against, the daily Press, public opinion, the advice of prominent labour leaders, and the

withdrawal of credit by merchants. The injunction issued by the Federal courts, the degeneracy of the ex-members who happen to hold managing positions in the tinplate mills becoming strike-breakers and teachers of strike-breakers, going among their former associates in unionism, tempting and seducing them from the standard of unionism by bribery and promises of prominent and steady employment; the unlimited use of money by the United States Steel Corporation, and its evident willingness to spend millions to teach green labour to become experienced and skilled. . . .

"The trust insisted that whatever mills they would begin to operate would have to be excluded from the list of mills that they would treat with the association for."

The most prominent effect of the strike has been to virtually wipe out the union in many of the leading districts, so that in the American steel trade, trade unionism was probably never so much at a discount and in such disrepute as at the present time. The majority of the important concerns have made new arrangements with their workmen, many of them less advantageous to labour than those previously in operation, and most of them expressly refusing direct recognition of unions, or union officials, as such.

Arbitration and Conciliation.

For a number of years past both employers and employed in the United States, and especially those in the iron and steel industries, have given much attention to the conditions under which conciliation and arbitration may be most usefully applied. One of the earliest to press this on their notice was the late Mr. Jos. D. Weeks, of Pittsburg, with whom I had again and again discussed the subject nearly thirty years ago, and to whom I had the privilege of giving assistance in the compilation of the various publications he had written dealing with those methods of settlement, based on my early experience of them in the North of England.

There are now four trades in the United States in which systems of arbitration as to specific disputes have been established in a formal manner and on a national scale. These are the stove-moulding trade, the general foundry trade, the machinists' trade, and the printing trade. In all of these cases the system has been established by a permanent written agreement between organisations of employers and employés, and did not rest, as in some other trades, on annual agreements regarding the conditions of labour, or on mere custom or tacit understanding. These permanent agreements in the first three trades named prohibit altogether strikes and lock-outs on the part of members of the organisations, and provide for the settlement of all differences by joint committees. In the printing trade the system of arbitration applies only in the case of such employers as enter into contract with unions to be subject to it.

I am told that in the iron and steel trade the constitution of the Amalgamated Association of Iron and Steel Workers directs the formation of mill committees to represent the employés in dealings with employers as to minor matters. Manufacturers who enter into agreements with the organisation bind themselves to recognise this mill committee. In case of failure to reach a settlement locally the

matter is to be taken up by the district officers of the Amalgamated Association in connection with the mill management. Although there is no provision for ultimate reference to a formally constituted joint board of employers and employés, or to an outside arbitrator, it is stated that the spirit of employers and employés is usually such as not to tolerate a cessation of work on account of local differences in plants where the Amalgamated Association is dealt with.

The tin workers' agreement with the American Tinplate Company provides for settlement of disputes by negotiations between the "mill committee" of the men and the employer, with appeal to the district officers of the union and the district manager, and ultimately to the same joint committee which adopts the annual agreements.

A recent pronouncement on the subject states that in a considerable number of States laws have been passed providing for permanent State boards of arbitration, and while in some of the States the laws have been almost dead letters, several of the boards thus established have accomplished noteworthy results. In other States the Legislatures have passed statutes encouraging the formation of local boards of conciliation and arbitration. In many trades the conditions of labour in not a few localities are determined by conferences between employers and employés or between representatives of organisations of employers and employés. These conferences often result in written agreements prescribing the terms of the labour contract for a given period of time. The practice is also growing of referring disputes, especially those relating to the interpretation of the labour contract, to committees representing the employers and employés, while in many instances impartial umpires or arbitrators are called in to settle matters as to which such committees cannot agree. The most conspicuous manifestation of the movement in favour of more harmonious relations between employers and employés is found in the systems of conferences and joint agreements covering trades throughout the entire country, or throughout large sections. In most of the 10 or 12 trades in the United States in which such wide-reaching systems exist, they have been established within the past 15 years, while fully half of the systems date back not more than five years.

In the case of the iron and steel trades the representative character of the conferences by which the annual agreements are reached is secured largely by the establishment of separate or branch committees for the distinct branches of the trade. These branch committees themselves usually consist of a considerable number of persons, ranging from five to 20 or more. They negotiate separately in the first instance as regards matters concerning their respective branches, but usually, if they fail to agree, reference is made to a general committee, which in most cases is composed simply of all the branch committees acting together. In two trades general agreements have been adopted by relatively small numbers of representatives. Thus in the stove foundry trade the collective bargaining is entrusted to the same "conference board," composed of the presidents of the national organisations of employers and employés and of three other persons on each, which arbitrates in minor disputes. It is probable, however, that other representatives of the respective organisations also attend the conferences, but with no voting power.

SECTION IV.

CHAPTER VII.

Organisation and Administration in Industrial Affairs.

WHILE the general tenour and specific facts of this Report are likely to afford some insight into the conditions of organisation and administration under which American works are carried on, there are a number of side-lights that can only suitably be thrown on the subject by devoting a special section to their consideration. These necessarily deal with some features that are more or less national and racial, with others that are due to climatic conditions, and with others, again, that are more or less of the original needs of the country—as of nearly all new countries—in respect of meeting wants that could not otherwise be met, by enterprise, energy, and adaptability. The latter are not new qualities, although Europe has given more attention to them of late years than formerly. More than sixty years ago "Sam Slick" declared that "We are all in a hurry in the States. We eat in a hurry, drink in a hurry, and sleep in a hurry. We all go ahead so fast it keeps one full spring to keep up with the others, and one must go it hot foot if he wants to pass his neighbours."

Attitude of Principals.

A writer on American commercial conditions recently ascribed the success of the American people in industrial affairs, not to the wonderful natural resources with which they have been endowed, but to their energy, perseverance, and hard work. "We succeed," it was remarked, "because we deserve to do so." While this may be looked upon as carrying self-complacency a little further than the strict tenets of modesty can sanction, there is much to be said for the deserts of American manufacturers. I found, for example, that in a large number of cases—probably, although I cannot verify this supposition, in the majority—the responsible partners are at their desks at or about eight in the morning, and remain there until at least half-past five or six in the evening. One case in point may serve for the whole. I had the opportunity of being brought into personal contact with three of the seven partners in the Baldwin Locomotive Works at Philadelphia. I asked one of these gentlemen at what hour the partners were accustomed to get to business in the morning. His reply was that they were rarely later than a quarter-past eight. This fact naturally suggests the inquiry: How many British manufacturers in equally influential circumstances would be found at their offices at the same hour? It

is no part of my business to investigate this point, but it is clear that if the number be small, and if the usual hour in Great Britain be an hour later, that hour spread over a week, even if compensated by an hour's longer work in the afternoon, is likely to be capable of estimation as a distinct loss. I may add that in other cases we found that the responsible superintendents or managers of works—as, for example, the Duquesne Works of the Carnegie Steel Company, where Mr. Parkes and myself found ourselves at a somewhat late hour—remained on duty until, or resumed duty at, a late hour of the evening.

In a recent article the *Philadelphia Times*, a journal of high character, speaking of the early and industrious habits of the Americans, remarked that "Many of the chiefs of our great industries are at their places of business at eight o'clock in the morning, and they remain there until the last working man goes home. Americans achieve success by hard labour."

How Men are Handled.

I could hardly fail to note that in the United States the keener rivalry and the more aggressive ambition to succeed, leads to less consideration for the feelings and fortunes of "the other man" than is prevalent in Britain. The British system, from the highest to the lowest, appears to have a basis of *esprit de corps*, reciprocity, and sentiment which is not so common in the United States. Trades unionism itself often has its foundations deep down in humane ideals, designed to achieve what are believed to be desirable ends of a collective, as distinguished from an individualist, character. But in the United States, due largely to the more cosmopolitan character of the country, it is every man for himself, and the result is often bad for the individual. Long contracts for services are rare. Generally speaking, men can be got rid of on a day's notice. The most faithful services are not accepted as a set-off against one mistake. In the higher walks of administration so much importance is attached to the spur of ambition or necessity, that in not a few cases men have been got rid of when they had attained a certain measure of wealth on the assumption that, having reached that standard, they would be likely to take things more easy. This has been notoriously the case in the Carnegie Company's concerns. It is a standing joke in Pittsburg, that when a partner in that enterprise is "sent to Europe," it is but an understood euphemism for having him got rid of entirely, and, if I am correctly informed, this has in several cases actually happened.

Between the British system of retaining a general or departmental manager until his working days are almost done, and the American system of getting rid of any man, however exalted his position, when there is the least evidence that his efficiency and his power of endurance are waning, there is a great gulf fixed, and I shall not be expected to discuss the ethics of the question. I would, however, point out that the obvious effect of the American system is to cause much more frequent changes in managerial positions than would be the case at home, and to lead men to strive, probably not always in the most commendable way, to bring about changes that may be expected to benefit themselves.

Demand for Efficiency.

Not only are the Americans ready to "scrap" ineffective and out-of-date equipment, but they are generally ready to expend large sums of money in undertaking experiments on new ideas that promise to lead to economy. One of the latest and most notable examples of this fact is the case of the Taylor-White process of treating tool steel, on which the Bethlehem Steel Company expended about 100,000 dols., and cut up over 200 tons of forgings before making it a success. Other cases are those of the experiments made by the late Captain W. R. Jones, of the Edgar-Thomson Steel Works, to get rid of the cracking of ingot-moulds after casting, and of the experiments made by the same engineer in order to prove the advantages of a mixer between the blast furnace and the Bessemer converter. But, indeed, the whole history of the American iron industry is studded with similar cases, and practically every enterprise of any magnitude can, and does, make claims of its own for important pioneering work.

Appreciation of Expert Ability.

One prominent feature of American administration is the care taken to secure the best advice and skill possible in the building of new plants, or the remodelling of existing plants, no matter what it costs. When in Cleveland, O., I was shown over the offices of the Wellman-Seaver Engineering Company and of the Garrett-Cromwell Engineering Company, both in the New England building. The former employs about 100 draughtsmen and the latter about 40. These figures will give an idea of the vast amount of work undertaken by both. This work is largely done in designing and perfecting appliances of different kinds. In the case of the Wellman-Seaver firm, one or two special businesses are carried on, such as the construction of retort coke ovens, on which the company owns certain patents. But a large part of its work consists in advising and preparing plans for clients who propose to build new plants—blast furnaces, steel works, tube works, tinplate works, and otherwise. The engineers employed by the individual manufacturing companies, although generally very competent men, are not expected to accept the full responsibility of such work. The fees paid for such outside assistance are, no doubt, considerable, but in the long run it pays well to adopt this system, because such firms of consulting engineers have a much wider range of up-to-date experience than any engineer employed at an individual establishment would be at all likely to possess.

The Daily Lunch.

Several Americans spoke to me in deprecatory language of the not uncommon practice in British works of providing a daily lunch at the offices for the heads of the departments, at which stimulants are taken. They declared that it was impossible for them to conceive of a man being as alert and capable after partaking of alcohol, whether as wine, whiskey, or beer, as he would be without it, and the argument is that the practice causes the efficiency of the work to suffer.

In the leading American works luncheons are similarly provided, but stimulants are very rarely placed on the table. In one or two cases where I was invited to join the managers at lunch, as at the Westinghouse Company's works, I found nothing stronger than soda-water and coffee. At the same time, I cannot but think that the Americans, in this criticism, overlook or minimise what is probably, to the average man, the more debilitating effect of their own continual smoking. In most of the works I visited, and especially in Pittsburg, where "toby" cigars are cheap, I found that nearly all the officials were greatly addicted to smoking, and that they smoked everywhere, both early and late.

Mr. Carnegie's Influence.

In speaking of the conditions that prevail in work, organisation, and administration at Pittsburg, it is impossible to ignore the influence of Mr. Andrew Carnegie. That remarkable man introduced a new force and a new order of ideas into American industry, the basis of which was that nominally high wages are, or should be, synonymous with cheap production. No one is likely to deny that his methods have raised the average level of both wages and efficiency throughout the sphere of his own operations, and probably far beyond it. At a meeting with his workmen some years ago, Mr. Carnegie claimed, and most probably with justice, that his workmen at Pittsburg, who then averaged over 2½ dols. per day, were the most highly-paid body of men in the world employed on a large scale. Moreover, Mr. Carnegie's system has stimulated effort on the part of all his colleagues to excel in their several functions, so as to be "at the top," and to keep there. The reward was generally well worth their utmost exertions to secure. No man and no system in this world has probably ever made so many men wealthy in so short a space of time. Under the Carnegie *régime* it has frequently happened that if a man had not broken down, mentally or physically, he had become a millionaire in the American sense in a very few years. The bonus system now so generally adopted throughout the workshops of the United States is but a modification of the Carnegie system of urging every man to do his best, and the same principles have been adopted by such great organisations as the Pennsylvania Railroad Company with notable results.

Nepotism and Merit.

So far as my information enables me to judge, there is probably not so great a tendency on the part of men in authority to drag relatives up with them, irrespective of actual merit and proved capacity, as in Great Britain. Two cases that are well known in the American iron trade might appear to point to a contrary conclusion, but in both of these cases I am informed that the utmost care was taken to establish the fitness of the men who were promoted before promotion was given. The cases where relatives are put before men who have earned a good position, merely because they are relatives, are comparatively rare, and even when they happen, the chosen one is made aware that he cannot hope to retain his position if he does not prove himself equal to any probable rival. The system of promotion by merit

apart from age, influence, or experience, could not otherwise be maintained.

Holidays.

In the United States, workmen's holidays are much less frequent than in Europe, and altogether there is much less broken time. In the majority of the works visited, I was informed that there were few worshippers of Saint Monday, and that the men were generally industrious, abstemious and well-behaved. "It is a common saying," said Mr. Pargny, who is proud of his labour at the Sheet Steel Company's Works, and is the virtual controller of Vandergrift, "that there are only two holidays in the United States—Independence Day (4th July) and Christmas." Americans profess great astonishment to learn that in Great Britain workmen take a week to ten days' holiday at a time, as in the case of the Glasgow Fair.

At the same time, after a considerable period of unremitting work, foremen, managers and others are often allowed a long holiday in Europe or elsewhere, at the cost of the firm. Mr. Carnegie, in my hearing, once remarked that he believed it generally paid to send a man to Europe, to pick up what ideas he could. I named this to one of my friends in Pittsburg, whose reply was that if it paid Mr. Carnegie to send a man to Europe, it did not always pay the man. The frequency of the visits to Europe of responsible heads of large concerns has now a counterpart in our own practice.

Arrangement of Departments.

The arrangement of the different departments of one of the so-called consolidations of American works, is a subject on which much might be written did my space permit. I can only stay to give a rough outline of the different divisions of a typical organisation, and shall, for that purpose, select the Pittsburg offices of the National Tube Company, which are arranged as under :—

President	Treasurer
First Vice-President	First Assistant Treasurer
Second Vice-President	Traffic Manager
Assistant First Vice-President	Traffic Department
General Sales Agent	Order Department
District Sales Agent	General Sales Agent
Auditor	Assistant-General Sales Agent
Statistical Department	General Superintendent
Purchasing Agent	Mechanical Engineer.
Purchasing Department	

The system of having all the offices concentrated in one building and on different floors is a great economy of time and labour. The Carnegie building in Pittsburg is a notable example of this fact; it has about eighteen floors, and about thirty rooms on each floor. But the Carnegie building does not stand alone. At the present moment Mr. H. C. Frick is erecting in that city a building which is nearly double the size of its neighbour—the Carnegie—and there are other similar

buildings, such as the Tradesmen's, the Empire, the Smith, etc. I present herewith an illustration of the Carnegie Company's Offices.

FIG. 23.—THE CARNEGIE COMPANY'S OFFICES AT PITTSBURG.

The Preference for Young Men.

One prominent feature of the administration of American works, and perhaps especially so of iron, steel and engineering works, is the

large number of young men who are to be found in positions of authority. This is founded upon one of the aphorisms of American enterprise—that a young man's intuitions are more effective than an old man's experience. The preference that Mr. Andrew Carnegie has always shown for young men is one of the standard facts of recent industrial history in the United States. Perhaps his most signal success in the selection of subordinates has been the case of Mr. C. M. Schwab, whom he appointed President of the Carnegie Steel Company when he was barely thirty years of age. The usual practice of Mr. Carnegie was to note the capabilities of his juniors, and advance them accordingly. This example has now been largely followed in other great enterprises.

As an example of the comparative youthfulness of the men who are charged with responsible positions, I probably could hardly cite a more striking case than that of the Pressed Steel Car Company, at Pittsburg—a concern that employs about 10,000 hands, at four works of unusual magnitude, and carries on a highly profitable business that has not only been developed, but also originated within the last four or five years. In this case I ascertained that the founder is 56 years; the president, 38 years; his assistant, 36 years; the chief engineer, 32 years; the consulting engineer, 42 years; and the secretary, 36 years of age.

Improvements and Inventions of Workmen.

Most of the leading firms of manufacturers in the United States make a practice of encouraging their workmen to give attention to possible improvements of processes and appliances, and offer premiums for new ideas of value. In some works an agreement is made as to this subject, one of which, as adopted at the works of W. Sellers & Company (Incorporated), will be found in the Appendix. Apart from premiums or prizes, awarded at the discretion of the employers, it is understood, as a rule, that the firm gets the full benefit of new ideas, but the workman has the advantage of knowing that if he succeeds in his efforts in this direction his services are more highly valued. This system also necessarily gives the workman more ready and more direct access to his employer and manager, and establishes a solidarity of interest that is advantageous to both.

The Telephone.

Among the accessories to the prompt, effective and vigilant transaction of business which are everywhere met with in the United States, to a much greater extent than in Great Britain, prominence must be given to the all but universal use of the telephone. This useful instrument is found in every office, in every industrial establishment, however insignificant, at every mine, and in almost every house of any pretensions. The manufacturer, manager, or other responsible head is thus in constant contact with his business, and there is seldom an hour when he does not know exactly what is going on and is not in direct touch with his subordinates. It is a matter of common knowledge that the use of the telephone in the United States is greatly more general than in Great Britain, and recent statistics show that

the total annual American output of new telephone instruments exceeds a million, and that the value of the telephone manufacturing industry in the United States exceeds 30,000,000 dols. a year.

When it is remembered that the telephone is only a quarter of a century old, and that in that comparatively short interval this gigantic industry has been built up to its present dimensions, we have before us another striking example of the readiness of the people of the United States to adopt anything and everything that will facilitate business, and economise time and labour.

The Direction of Works and Mines.

One of the most notable features of the management of American works is the comparatively rare presence on a board of directors of the merely commercial man, who is there in virtue of his holding a large stake in the concern as a capitalist. Every man engaged in the management of an American manufacturing concern, with occasional exceptions, is expected to give practically his whole time to the business. The custom so general in Europe of paying men fees as directors who merely attend a meeting once a month is most uncommon. Generally speaking, the executive of a large American concern consists of a president, one or two vice-presidents, a secretary, a treasurer, and a sales-agent, with their subordinates. Every one of these men is expected to give his entire time to the duties of his position, and he would not be permitted to hold office on any other terms. Every one, also, has his range of work specifically defined in such a way that in well-managed concerns there is no overlapping or confusion.

It is to this exclusive employment of capable and practical men that the American iron and engineering industries mainly owe it that they can and do make such rapid progress in the adoption of new ideas, systems, and appliances. One controlling principle in many European concerns is never to spend any money that can be avoided. Another is never to do to-day what can be put off till to-morrow. The average European director—that is, the typical member of a typical board—is mainly a commercial man, and he looks with suspicion upon all proposals founded on the expenditure of large sums of money. He may not realise the importance of keeping up the efficiency of the plant and equipment to the highest level, and he is more or less liable to distrust managers and managing directors, who are what are called "expensive men"—that is to say, men who are mainly concerned in economising production, almost regardless of present outlay. A recent writer remarks, with regard to German works, that "capability is not wanting, but the large body of mechanical workers is spoiled by mismanagement and bad supervision," and that "incompetent technical superintendents hold positions secured through influence by the commercial directors, who have no knowledge of mechanical requirements or of the industrial situation, and have, moreover, no appreciation of practical results."* "English industrial enterprises," it is added, "are in some respects in the same condition."

* *Engineering Magazine*, vol. xvii., p. 19.

The British Element.

There is a not uncommon idea in Great Britain that the people of this country have lost a lot of their old grit, and that they have more or less deteriorated as business men. This is not a point that I am called on to consider here, but I mention it because in the course of interviews which I have had with leading Americans, I have found that they did not share so pessimistic a notion. What they said and seem to think is this: That the people of the old country had for generations, as they expressed it, made their money very easily, having practically all the markets of the world at their feet; that this enabled them to acquire great wealth, and made them indifferent to undertaking exertions to make more; that their descendants had succeeded to wealth and position, which made them indifferent also; and that enterprise and efficiency were thus to a certain extent allowed to go by default. But the grit is still there; it only needs to be stimulated and encouraged.

That this is not an entirely erroneous view of the situation is proved by the fact that a considerable number of the heads of the American iron industry of to-day acquired their training, their knowledge, and their experience in British works. In my journeyings I found many men in the most responsible positions who had been brought up in Scotch or English works. Mr. William Garrett, the inventor of the Garrett rod-mill, himself a Scotchman, has confirmed the view that the native American has no innate superiority, apart from his restless activity, and some of his methods.*

Hustling.

The remarkable quickness with which the American system of hustling enables work to be got out could be illustrated by many examples, in practically every department of the iron and steel industries. Let one example suffice. For the McKees Rocks plant of the Pressed Steel Car Company, where 13 acres are covered with steel buildings of the most modern type, ground was broken in April, 1899, and the first complete cars were delivered from the new plant less than six months afterwards. The capacity of this plant, it may be added, is about 80 complete 35-, 40-, or 50-ton cars per day.

The enormous scale on which new works are laid out from the beginning may be illustrated by the case of the two plants of the same company at Pittsburg. These works are practically only three years old, but they have already turned out more than 50,000 cars, varying in capacity from 20 to 50 tons each, and at the time of our visit they had orders on hand for 1,500 more.

A great deal might be said on the hustling habits of the Americans, and of the manner in which, and the extent to which, they influence all their work. It is a quality which seems to me to have its origin in a superabundance of vitality, a love of work for its own sake, and a universal desire to be "at the top," which permeates every stratum of the commercial and industrial classes. In some respects it may not be the most estimable of qualities, but it has gone far to make the Americans what they are to-day.

* See Mr. Garrett's letter in the *Iron and Coal Trades Review*, January 10th, 1902.

"At War with Clumsiness."

Generally speaking, the typical American likes what is called a "neat job," and his works and plant are usually to be found in good order, as well as up to date. The *Iron Age* recently declared that "Few people on the face of the earth are so perpetually at war with clumsiness and even the appearance of heaviness as Americans. Safety and durability are not lost sight of, but are always carefully considered, after which comes the question of avoiding the use of surplus metal, except in cases in which very great strength can only be secured by means of ponderous masses of material. But in building machinery for light manufacturing, or for rapid movement, or for agricultural purposes, everything in the nature of surplus weight is rigorously eliminated. Agricultural implements and vehicles, as made by American manufacturers, are almost marvels of lightness and strength, so thoroughly has the question of easy draft been studied. In mechanics' tools, hardware specialities, builders' hardware, saddlery hardware and house furnishing goods the same conditions are apparent. Mere dead weight is avoided unless it is an essential feature of the article itself."

Workmen Checking Their Own Work.

One of the most effective methods for securing good work that I was made acquainted with during my inquiries, was that of making one set of workmen check the labour of others, from the most rudimentary to the highest piece of work. This is done by the adoption of a rule that a separate group of men shall be employed for each separate operation. The cases in engineering works in which there may be half a dozen or more operations in producing a particular piece of work are not uncommon, and in every such case, the man who is responsible for the next operation, being also responsible for passing on his work to his successor in a proper condition, must, in his own interest, take care that he receives it without defects. Otherwise, it is his business to report what is defective. I found this system in operation at the Baldwin Locomotive Works and the works of William Sellers & Company, in Philadelphia, and I was informed that it was an excellent method of ensuring that no bad or scamped work is passed out.

Intelligence in Industry.

"In strict proportion to their eagerness for foreign markets," says Mr. Pidgeon, "American manufacturers will presently realise that they possess advantages in readiness to learn, quickness to adapt, and skill to organise over every other nation in the world, while the labour they command is high-principled, intelligent, and industrious in no common degree. Men with such cards in their hands will not hesitate to sit down for a commercial rubber with Europe, when protected manufacture has degenerated, as it is already rapidly doing, into a game of beggar-my-neighbour."* This is the expression of a writer of much acumen, who was himself a British manufacturer.† Since these words

* *Old World Questions and New World Answers.*

† Mr. Pidgeon was a member of the firm of B. Samuelson & Company, of Banbury.

were written, much testimony of a kindred character has been supplied by other acute observers, pointing to similar conclusions, and by the recent industrial history of the American people.

American Patents.

A great deal has, at different times, and in a number of publications, been said as to the conditions that distinguish the American from the British patent system, and in the majority of cases an adverse verdict has been pronounced against the British Patent Laws. It would take up far too much space, and serve no very immediate purpose, to join here in this controversy. In both cases the business done under the Patent Laws is enormous, in both the cost is considerable, and in both there is a surplus left to the Government on the result of the year's working, over a long series of years. During the last fifty years the total number of applications for patents in the United States has increased from 2,639 to 47,905, this latter having been (in 1897) the largest number ever recorded in a single year, and yielding a total sum to the Patent Office of 1,375,641 dols., of which 252,798 dols. was left over as a surplus. But the total number of patents and re-issues actually granted has usually been less than one-half the total number of applications.

The statistics of patents granted in the United States to foreign inventors shows that England maintains her lead, with Germany a good second. There were granted to residents of England 1,072 patents, and to those of Germany 888, while Canada received 371, and France 292. In making a comparison of the past four years we find evidence of a growing appreciation among foreign nations of the value of United States patents. The most remarkable figures are those for England and Germany, which have risen respectively from 617 to 1,072, and from 543 to 888. Canada, although possessing not over one-sixth the population of France, is a more frequent applicant at the United States Patent Office, 371 patents being granted in Canada as against 292 in France. Indeed, in proportion to her population, Canada takes out by far the most American patents of all foreign countries.

In considering how to deal with new inventions, the American manufacturer usually determines whether he shall take out a patent or not by the consideration of how far it is intended to manufacture and sell the idea or the machine, as distinguished from only using it for his own works or purposes. If he intends to sell, of course he must make it known, and then it pays to take out a patent, but there are hundreds of most valuable ideas in use in American workshops that have never been patented, and many of which cannot be found applied elsewhere.

American Publicity v. British Reticence.

There can be but little doubt that the progress of the American iron and machinery trades in foreign markets has been greatly facilitated by the greater readiness with which the manufacturers of that country make known the contracts which they have succeeded in securing. There is much less hesitation in the United States

in taking the general public, so to speak, into the confidence of the trade. In Great Britain there appears to be a decided objection to make known what manufacturers are doing. So far as I have had the opportunity of forming an opinion, from frequent discussions of the subject, I am inclined to believe that this is largely the outcome of a fear that if the customers of a firm are disclosed, rival manufacturers will make use of the information to their detriment. British manufacturers are probably not all influenced by this consideration. It may be that their natural reticence and conservatism have even more to do with their objection to publicity than the fear of rivals.

In any case, it is probable that the American system is better calculated to assure the success of American trade, inasmuch as it not only enables the whole world to learn what the Americans are doing, but it also leads to the inference that their rivals, whether British, German, or Belgian, are unable to compete with them, and nothing is more natural than that this fact should lead the purchasers of the manufactures thus heralded to believe that American goods are cheaper, or better, or both.

Another consideration that has been not a little hurtful to British traders is the fact that in a number of cases incorrect statements have been made in the public Press as to contracts having been booked by Americans, whereas those very contracts have fallen to British firms.

SECTION V.

CHAPTER VIII.

Transportation Systems and Conditions.

General Survey of the Position.

Introductory.—No one familiar with the recent conditions of trade in the United States, and with the mining and metallurgical industries in particular, can fail to realise the importance of the effectiveness and economy to which that country has brought its transportation systems, both by land and by water. This is a matter to which I have for many years devoted much attention, and I may be pardoned if I here point out, as a possible justification of the space which I may devote to this aspect of my subject, that it is nearly twenty years since I called the attention of British railways and British traders to the character and importance of the movement then recently inaugurated in the United States, for making use of larger locomotives, larger mineral wagons, heavier permanent way, and other changes that have done much in the interval to provide cheaper transport.*

Again, some years later, when the Railway and Canal Traffic Act of 1888 was being discussed before the Board of Trade Commission, as representing the British Iron Trade Association I had the opportunity afforded me, when the late Sir George Findlay and Mr. Lambert, managers of the London and North-Western Railway and the Great Western Railway, respectively, were under examination, of ascertaining from them that up to that time little or no interest had been taken by British railways, as such, in the leading features of American railway administration, on the ground that the conditions of the two countries were so dissimilar that there was little in common between them, and it was not thought that any lessons of value to this country could be learned from a study of American systems. This, *mutatis mutandis*, has been the general attitude adopted in regard to American railways until the coupler question was, a few years ago, taken up by the Board of Trade, and British railways were more or less forced to give attention to American organisation. Much has happened since then, and not the least important of the many changes that have marked the interval has been the close attention now given to American railway

* *Railway Problems.* London: Longmans.

affairs by British railway managers, and the adoption by some of them of features and methods that are now being applied on our own lines, with promise of notable advantage.

It has been my good fortune on three previous visits to the United States to see much of American railroad systems, and to come a good deal into contact with American railway managers and officials. I have again and again travelled over the principal lines of the country, from Houghton and Marquette, on Lake Superior, to Texas in the south-west, and to Alabama in the south. I have studied the system in the eastern and middle States, where the traffic is as dense and concentrated as in any part of our own country, and again in such virgin and undeveloped fields as Indian Territory and Oklahoma. I mention this merely as an indication that I have not been without some experience of the working of American railway lines.

While we were in New York we were told, and by no less an authority than Mr. C. M. Schwab, the president of the United States Steel Corporation, that one of the chief causes of our not maintaining our place in the world's commerce was the defective character of our railway organisation, and the consequently high railway rates generally charged. It is now some years since another notable authority on American transportation—Mr. Andrew Carnegie—told me that in his opinion the best thing that could happen in the interests of British traders would be to have British railway companies make a bonfire of their rolling stock generally. With the latter gentleman—himself at one time an experienced railway manager—I have often during the last 20 years had valued opportunities of comparing notes on American and British railway conditions. I mention this because it gives me the opportunity of adding that which I think is the barest justice to his life's work, that I know of no man who has done more to stimulate the American railway managers to improve methods and reduce rates than Mr. Carnegie, as I shall have occasion hereafter to show.

With the view of obtaining the best and latest information available on the subject of railroad transport, I visited, with Mr. Parkes, the offices in Washington of the Inter-State Commerce Commission, where the president, vice-president, and secretary most kindly received us and gave us valuable information. I also called on Mr. Theo. N. Ely (the chief of motive power of the Pennsylvania Railroad at Philadelphia), with whom I had a long interview, and from whom I also obtained important data; visited and had interviews with the chief proprietors of the Baldwin Locomotive Works; called at the offices and interviewed the chief officers of the Lake Erie Transportation Company; and obtained at Pittsburg some most important figures as to the cost and the conditions of working an almost exclusively mineral line from the lakes to the busiest centre of American industry.

In considering the general subject of railroad transport, it seems necessary to first endeavour to determine approximately the differences of cost in the two countries, and then to ascertain, as far as possible, how those differences are caused, and what are the prospects, if any, of applying a remedy, where they are against this country.

A.—RAILROAD TRANSPORTATION.

1.—British and American Railway Charges.

There is no authoritative statement of average British rates to appeal to. In the United States, however, and in almost every other country except our own, ton-mile figures are a prominent feature of railway accounts. This distinction renders comparisons difficult. The train-mile, which is the unit adopted in British railway accounts, is no guide whatever to rates and charges, and is apt to mislead in other ways. Some years ago, the United States Inter-State Commerce Commission adopted 1½d. per ton-mile as the average charge in Great Britain, but, in my opinion, without sufficient ground. The nearest approach to a reliable figure that I have yet found was given recently by Mr. George S. Gibb, the general manager of the North-Eastern Railway, as 0·99d. per ton-mile for mineral traffic.

The Pennsylvania Railroad.—There are probably very few railways in any country on which the statistics of operation are so fully kept and so easily comprehensible as the Pennsylvania. That colossal system, with 3,715 miles of road operated directly, with 88½ million dols. of gross earnings and 58 million dols. of operating expenses, in the year 1900 carried about 109 million tons of traffic, and moved 11,922 million tons of traffic one mile, the freight earnings for the same year having been about 64½ million dols.

It is important to note the treatment accorded to the traders on its system by this great line, because no railway in the world serves such a vast congeries of iron and steel works, and mining and industrial enterprises generally.

The records of the company show the earnings, the expenses, and the net earnings per ton per mile for the last thirty-six years, and the lessons which these records teach are of value to railway corporations and traders generally. Since the year 1865, the record has been one of uninterrupted progress in economy of working and in the reduction of freight charges. In that year the figures under the heads stated were—in cents per ton-mile in all cases:—

Average Gross Earnings.	Average Expenses.	Average Net Earnings.
2·715	2·347	0·368

Even at this early date, it would appear that the profit per ton per mile did not exceed 14 per cent., while the working expenses were over 85 per cent. of the total gross earnings. By 1880, a great change had taken place, as the following corresponding records show—again in cents per ton-mile:—

Average Gross Earnings.	Average Expenses.	Average Net Earnings.
0·918	0·540	0·378

Here we find the gross earnings reduced by 66 per cent., or, in other words, they had been lowered to about one-third of what they were 16 years before, while the operating expenses had been reduced to less than one-fourth the figures of 1865. The average net earnings, on the contrary, had slightly increased.* When we carry the com-

* In explanation of this fact it may be stated that in 1865 the average net earnings were under those of both previous and subsequent years.

parison a little farther, we find still more notable progress, for in 1890—the year when the Iron and Steel Institute members visited the United States, and were afforded the opportunity of witnessing for themselves how the Pennsylvania Railroad Company handled its traffic—the figures had been reduced as shown below—in cents per ton-mile:—

Average Gross Earnings.	Average Expenses.	Average Net Earnings.
0·655	0·463	0·192

Many railway authorities at this stage entertained the idea that economy could no farther go. Nevertheless, the earnings, the expenses, and the profits were alike reduced in the following ten years, as shown for 1899 in the next set of figures, recorded in cents per ton-mile:—

Average Gross Earnings.	Average Expenses.	Average Net Earnings.
0·473	0·344	0·129

These are the lowest average earnings per ton-mile, as well as the lowest average expenses and average net earnings ever recorded on the Pennsylvania system. For the year 1900 the average ton-mile earnings had risen to 0·540 cents, while the average expenses had risen to 0·364 cents, and the net earnings had risen to 0·176 cents.

It will be noted that, taking this period as a whole, the ton-mile earnings of 1899 were only about one-sixth of those of 1865, while the working expenses were about one-seventh, and the net earnings about one-third of those of that year.

This revolution has not been confined to one American railway, but is more or less common to all the great mineral-carrying lines of the country. It has mainly been achieved by extraordinary economies in every department of operation and control, and it is of interest to be able to set out in what departments the principal reductions have taken place. This I am able to do by the kindness of Mr. Theo. N. Ely, who, in the course of an interview that I had with him at his office in Philadelphia, gave me particulars of the reductions in the costs of working that he had been able to effect during the last twenty years.

The Pennsylvania and the North-Eastern Systems.

The Pennsylvania Railroad is operated under conditions vastly different from any that prevail in this country, or, indeed, in any part of Europe. I have taken some trouble, from records furnished me by Mr. Ely, to work out an analysis of mineral traffic on the Pennsylvania system in 1900, and I find that the total volume of traffic carried in that category was about 84 million tons, of which about 71 million tons were coal and coke, and iron and other ores, and the remainder was pig and other iron and steel.

The greatest mineral-carrying line in the United Kingdom is the North-Eastern, which in 1900 carried 41¼ million tons, or a little under one-half of the total mineral traffic carried by the Pennsylvania. The comparison, however, only begins here. The Pennsylvania carried its whole goods and mineral traffic an average distance of 109 miles, while the North-Eastern average was probably no more than 22 miles,

or say about one-fifth of its great American compeer. This difference is fundamental. The greatest authorities on transport are pretty well agreed that it matters a great deal, in fixing low rates, whether the haul is long or short, and that it is practically impossible to carry short-haul traffic for anything like the charges that can easily be applied to long-haul loads.

After making full allowance for this consideration, the difference between the British and American systems is remarkable and calls for explanation.

It is pretty certain that the average length of the haul of all mineral and merchandise traffic on the North-Eastern Railway—which we may again select as a typical line—is not a third, and probably not more than a fourth of that of the same description of traffic on the Pennsylvania system, and yet I find, on examination of their records, that the gross receipts per ton moved in 1900 works out to just the same figure, namely, 2s. 3d., while on the North-Eastern the average gross receipts for mineral traffic in the same year were 1s. 5d. per ton.

It will probably strike others besides myself as remarkable that the capital expenditure of the North-Eastern Railway Company is greater than that of the Pennsylvania, the former being over 73 millions, while the latter is about 67 millions sterling. The expenditure of the Pennsylvania per mile of line is given at the following figures in that company's statement of accounts:—

Cost of Road	£3,300	per mile of line.
„ Land	1,155	„ „
„ Equipment	2,400	„ „
Total	£6,855	„ „

The system adopted by the Pennsylvania Company in making up their accounts renders it difficult to understand exactly of what the difference between these figures and the £18,000 per mile at which the line is capitalised—entered as "assets" in the report—is made up, but excepting for terminal property, the difference does not appear to belong to either the construction or the equipment of the lines directly owned and worked by the undertaking.

Against this, to quote again the case of the North-Eastern Railway, the capital account of that concern represents an average expenditure of over £44,000 per mile. The mileage of the Pennsylvania line is 3,716 miles, while that of the North-Eastern is 1,654. The two companies had at the end of 1901 the following equipment:—

	Pennsylvania.	North-Eastern.
Locomotives	1,889	2,121
Passenger Cars	1,779	2,884
Goods and Mineral Cars ...	52,784	98,248

Here the great disproportion in the numbers of vehicles, including locomotives, and the volume of business transacted, calls for a remark. The records of the Pennsylvania Company show that the average

train load over the whole system in 1900 was 478 tons. No similar record exists for the North-Eastern, but a recent article in a British newspaper, based ostensibly on information supplied by Mr. George S. Gibbs, the general manager of the system, stated the average to be under 100 tons.

In quoting the special case of the North-Eastern system, I wish it to be clearly understood that I do so not because of any idea that it is exceptional among British railways, or is specially calculated to supply an effective contrast. On the contrary, it may be taken as probably a favourable type of British mineral-carrying lines, having a lower capital outlay per mile, a larger equipment, a better service, and lower rates than a number of other British railways.

I should like to add a few words at this stage on the effect of low railway rates. In his elaborate statistical paper on "The American Iron Trade, and its Progress during Sixteen Years," in the special volume published on the occasion of the visit of the Iron and Steel Institute to the United States, Sir Lowthian Bell, with whom I had had a good deal of previous correspondence on the subject, takes me to task for a remark that "American railways had attained a degree of economy to which our railways are strangers," and for recommending British railway managers at that time to "adopt certain specified changes which had been proved so beneficial in the United States." I had shown the remarkable decrease of rates and increase of traffic between 1869 and 1888, and had argued that "the low freight rates of American railways have greatly stimulated traffic, while the high rates of British lines, if they have not absolutely hindered the development of traffic, have kept it from assuming the proportions it would otherwise have attained," and I expressed the belief that a still further reduction of American railway rates was to be anticipated. Sir Lowthian refers to these points I had then made as if they were at least doubtful, and reflects on the American lines for their high percentage of working expenses on gross receipts, adding that it was doubtful whether American engineers "would altogether endorse" my inferences, or "agree in the advice tendered for the guidance of English boards of (railway) directors."

What has happened in the interval? In the case of the Pennsylvania Railroad the average earnings per ton-mile fell from 0·686 cents. per ton-mile in 1888 (the year of which I wrote) to 0·473 cents in 1899, a decrease of over 30 per cent., so that I was correct in anticipating further reductions; while as regards Sir Lowthian's reflections on American railway practice, it is surely enough to point to the fact that within the last two or three years most of the responsible managers of the great British railways have visited the United States for the purpose of borrowing from their experience, and some of them—including the very line of which Sir Lowthian is a director—the North-Eastern—have gone, or are going, a long way in the direction of adopting American ideas and methods.

I do not introduce this episode for the purpose of justifying one writer as against another, but to point to the fact which I argued twelve years ago with the hon. baronet named, and earlier still, before the Commission of the Board of Trade on the Railway and Canal

Traffic Act (1888), that low railway rates do stimulate traffic, and hence to a great extent the wonderful development of American railways, while high rates hinder such development. The North-Eastern directors appear to have realised this law, and are at last doing something to facilitate its operation.

Causes of the Lower Range of American Rates and Charges.

Perhaps it hardly needs to be pointed out that some of the chief causes of the lower rates which the railway companies of the United States are able to charge are, in the order of occurrence—first, the cheaper cost of construction; second, the greater competition, owing to there being practically free trade in transportation; third, the less amount of handling done by the railway companies in relation to the length of haul; fourth, the stimulus to secure and develop traffic; and fifth, the economies in the conditions and cost of transport introduced within recent years. These are not submitted as the whole of the causes, but they are the most important.

In Great Britain these influences are usually conspicuous by their absence. The average cost of our lines has been three to four times that of American railways, taken as a whole.* We have no free trade in railways, and not much effective competition. There is a very great amount of handling done by the railway companies in relation to the length of haul, which probably does not exceed 35 miles, against about 112 miles in the United States. Too little is done to stimulate and develop trade by concessions in freights or facilities. And economies in the cost of working, in the largest American sense, have hitherto been too much neglected.

Some of the Lowest Transportation Costs on Record.

Some features of the low railway rates in the United States may be gathered from an examination of the conditions which prevail on what is probably the most effective railway system in the world, from the point of view of economical transport, namely, the Pittsburg, Bessemer, and Lake Erie Railroad Company, of which the Carnegie Steel Company were the powerful promoters, and in which they possess a controlling interest. From Mr. C. M. Schwab, and from Mr. Uttley, of Pittsburg, the manager of the undertaking, I obtained some interesting details of this line, which is illustrated in the diagram herewith (Fig. 24).

The president of the United States Steel Corporation stated that on this railway, between Lake Erie and Pittsburg, iron ore is carried for 40 cents (1s. 8d.) per ton over a distance of 156 miles. This means that the cost per ton per mile is little more than one-eighth of a penny. I may again be permitted to compare this figure with that recently given by the general manager of the North-Eastern Railway, namely, that the average ton-mile rate charged for the transport of minerals on that system during the month of May, 1901, was 0·99d. per ton-

* By dividing the mileage into the whole authorised or paid-up capital expenditure, I find that in 1900 the average capital per mile of line was £63,890 in England, and £12,437 in the United States. In Scotland the average is £47,500 per mile.

mile. This figure is nearly eight times as much as the actual cost given by Mr. Schwab for carrying kindred traffic on the American line!

There are, of course, essential, and even fundamental, differences

Fig. 24.—Map Showing Route of, and District Served by, the Pittsburg, Bessemer, and Lake Erie Railroad.

between the two cases which it would be improper to ignore. The average length of haul, is, in the case of the Carnegie line, from six to seven times that of the North-Eastern. Then, again, the Carnegie line was specially constructed for mineral traffic, and is worked with rolling stock that enables the tare to be reduced to a minimum

as well as the labour and cost of handling. Finally, on the American line the traffic is carried under conditions that enable much larger train-loads to be moved than would be possible in this country under existing conditions.* If similar information were obtainable as to other British lines, it would not be found that the North-Eastern system was relatively high in its charges for transport.

Mr. Uttley gave me a copy of the report on the operation of his railroad for the year 1900, from which I find that the total freight traffic carried on the system in that year was 4,180,391 tons, or a total of rather over 521½ million ton-miles, and as the gross freight traffic receipts for the same year was 2,112,860 dols., it would appear that the average receipts per ton-mile amounted to two-tenths of a penny (0·20d). The average length of the haul was 121·78 miles, the average live load per train 868 tons, and the number of trains required to haul the freight traffic above given on this basis is stated as 4,993. The average tonnage carried in each loaded car was 37 tons, the average number of loaded cars in a train was 23, and the average number of empty cars was 15. The freight traffic included 2,694,780 tons of iron ore, so that this mineral was 64 per cent. of the total freight carried.

The same statement shows that the total cost of the line and its equipment was 25,906,655 dols., or (converting the dollar at 4s.) £5,181,331, being an average of about £25,000 per mile, taking the length of the line as 203 miles, including branches. This is not much more than one-half of the cost of the North-Eastern system, as measured by paid-up capital.

Mr. Uttley was good enough to give me some particulars as to the grades of this interesting line. The heaviest is 39 ft. in a mile. In the first 14 miles of the route from the docks at Conneaut to Pittsburg, the ore is carried to a place called Albion, which is at a level of a little over 300 ft. above the starting point. The train is aided by an auxiliary locomotive, described as the "pusher." At Albion the trains are sorted and made up, and thence each train is taken for a further 15 miles by a single engine, when the steeper gradient compels the use of the "pusher" engine for five miles, from which point a single engine suffices for the next 20 miles. Here there is a grade of about 200 ft. in five miles, to overcome which the company are now expending 350,000 dols. in making a reduced gradient, by which it is proposed to get the trains taken right through by a single engine, instead of having to resort to two "pushers." At one or two other points on the line the aid of a second engine is called for, but only for a few miles, so that altogether the extent of the need of a second locomotive is not more than 15 to 20 miles between the harbour at Conneaut and the sorting yard at North Bessemer, near to Pittsburg, which is the terminus of the line.

At North Bessemer there is a large sorting yard, capable of providing for about 2,000 cars, of 40 to 50 tons capacity each, or 90,000 to 100,000 tons of material. Here another system, designated the

* It has recently been reported that the North-Eastern Railway Company has arranged to apply the American system of larger engines, rolling stock, and train-loads, to at least part of their traffic.

Union Railway, takes up the traffic and distributes it as required among the various concerns that make up the vast manufacturing resources of the Carnegie Steel Company.

The capacity of the various blast furnace plants of the company in and around Pittsburg, being over 3,000,000 tons of pig-iron per annum, the total quantity of iron ore that has to be handled in the course of the year must be over 4,000,000 tons. The whole of this great volume of traffic has to be carried to Conneaut during the summer season, as the navigation of the Great Lakes is only possible for about seven months of the year. During the other five months the ore is carried from the stock yards to the furnaces as it may be required. The pressure on the ore-carrying railway is thus much greater at one period than at the other.

There is a certain amount of interchange of traffic between the Carnegie Company's line and one or two other lines serving the same district, and hauling the same sort of traffic—notably the Pittsburg and Western and Lake Erie lines; and an increasing quantity of return freight from the Pittsburg district, including coal, is carried for the use of the towns on the Great Lakes, but at extremely low rates—the lowest, in all probability, in the records of mineral transport.

Mr. Uttley informed me that in the month of August, 1901—the month immediately preceding my visit—the total tonnage carried over the Carnegie Company's line was 729,288 tons, of which 550,504 tons were ore from Conneaut to Pittsburg, so that the return freight was very considerable. In the same month the average earnings for each ore train were 931 dols. 47 cents. The extent of the employment of the "pushers," or auxiliary engines, represents an average employment of $1\frac{1}{8}$ engine for the whole distance of 156 miles, and this is naturally found to be more economical than the use of two engines throughout.

Each train "crew" consists of a conductor, an engineer, a driver, a flagman and two brakemen, all of whom go with the train from end to end, while the auxiliary engines, with engine-drivers and firemen, go only part of the way, and unitedly represent one-eighth of the cost of a full "crew."

Since the Bessemer line is a private enterprise, conducted under exceptional conditions, it is natural that its affairs cannot be too fully disclosed. I was afforded the opportunity by Mr. Uttley of examining some of its working costs, but I am not authorised to give the details here. I may, however, say that the particulars which the company have thought fit to make public show that the traffic can be worked with a handsome profit at 3 mills per ton-mile, which means that the ore traffic can be carried over the whole distance of 156 miles as a profitable commercial enterprise, as stated by Mr. Schwab, for the sum of 1s. 8d. to 1s. 10d. When one thinks of the rates charged on British railways, as typified by the normal charge of 10s. to 12s. for the transport of pig or other metal from South Staffordshire to London, a distance of 120 miles, and by a charge of 7s. 6d. for carrying a ton of coke from the South Durham coalfields to West Cumberland, an average distance of less than 100 miles, this

American ore-carrying line surely suggests great possibilities in the way of cheapening British mineral transportation in the future.

Railway Rates and Facilities of different Iron-making Districts.

Of the two branches of the subject of railroad administration in which the British iron trade is mainly concerned, one—the differences in the conditions of the two countries—has already been considered. It now becomes necessary to consider the second—the differences in the facilities possessed by the leading iron-making districts of the United States, both for the economical assemblage of materials and for the development of an export trade.

Sources and Character of Information as to Rates.—In seeking for information on this latter part of the case, I found the greatest possible readiness to give actually quoted rates, which indeed are available to everybody. One friend in Pittsburg handed me a little booklet which contained some 30,000 different rates from that city to every part of the United States, got up for one branch only of the iron trade. Perhaps, naturally, I did not obtain particulars of special rates, under which, I have reason to believe, a good deal of traffic is carried by the larger corporations.

I deemed it expedient, in investigating this subject, to invoke the aid of the Inter-State Commerce Commission, which was established nearly 20 years ago for the purpose of dealing with matters that come up in the management and reciprocal relations of railroads, and especially with questions of rates for inter-State traffic. The Hon. Martin A. Knapp, the chairman, the Hon. Judson C. Clements, the vice-chairman, and the secretary of the Commission, in a long conversation on the conditions of American transport, satisfied me, at any rate, that transportation is not carried on, even in the United States, without a considerable amount of friction between the railroads and the traders, and that the latter have not always the same ready remedy that they have, within certain limits, in this country, where the rates are fixed by Act of Parliament, and where the Railway Commission has the power to determine what rates are proper and reasonable. Indeed, the president of the Inter-State Commerce Commission, in reply to my enquiry, admitted that that body had not at present the power to enforce any particular rate, or to compel even the highest rates to be modified. They can, he stated, only recommend an alteration, and the railroad concerned may either accept or reject the recommendation, although, as a rule, it is acted on.

I asked the chairman and secretary of the Commission if they could aid us by procuring, for our use, a statement of the amounts of the rates, mileages, and ton-mile rates of the coal, iron, and steel traffic carried on American railroads, and especially that part of such traffic as was destined for export. Both gentlemen readily undertook this service, and at a later date I received from them a series of interesting tables, communicating the information asked for, and on which I shall now proceed to make a few remarks. (See Appendix.)

Let me here state that these special tables furnished by the Inter-State Commerce Commission appear to me, with a fair knowledge of the literature and documents pertaining to American railroad affairs,

to furnish perhaps the most complete presentation of rates on coal and iron that is in existence. It is a rare thing to find American rates worked out as these are, so as to show at once the rate, the mileage, and the ton-mile records. The Commission took more than two months to collect and collate these figures, for which they made direct application to the various railroads concerned.

Coal and Coke Rates.—So far as coal is concerned, the rates are given for a number of principal points, in respect of the principal coalfields of Pennsylvania, Virginia, Western Virginia, and Maryland, in cents and decimals thereof per ton per mile. The most superficial examination of these figures shows the great influence of distance in American transport. Thus, from the Pittsburg district, the ton-mile rate for coal sent to Buffalo, which is 235 miles distant, is 0·43 cents, or 0·21d., but when the distance is doubled, as it is to Chicago, the ton-mile rate is reduced to 0·37 cents, or 0·16d.

These figures, again, should be helpful to those who are seeking to estimate the future of the American coal trade from an export point of view. Thus, it is shown that the rate from the Pocahontas coalfield—which is one of great promise—to Norfolk, which is the most important of the available ports, is 1 dol. 70 cents, or about 7s., and the rate is the same from Roderfield, in West Virginia, although 40 miles further off. None of the rates quoted for coal traffic to southern ports fall below this figure, but it is well known that some two or three years ago coal was being carried for export to some of the southern ports at about 1 dol. per ton.

The following is a statement of the freight rates on Connellsville coke to the principal points of consumption, from which it is possible to compute the cost of coke at the leading iron-making centres, taking the current price of the coke at the ovens, loaded into cars, at 2 to 2½ dols. (8s. 4d. to 10s. 5d.) per ton.

Points.	Dols.	Points.	Dols.
Pittsburg, Pa.	0·75	St. Louis, Mo....	2·95
Mahoning and Shenango Valleys	1·20	East St. Louis, Ill....	2·65
Cleveland, O.	1·50	Cairo, Ill.	2·65
Buffalo, N.Y.	1·75	Joilet, Ill.	2·50
Detroit, Mich.	2·25	Peoria, Ill.	2·55
Cincinnati, O.	2·00	Baltimore, Md.	1·95
Toledo, O....	2·25	Boston, Mass.	3·20
Columbus, O.	1·55	New York, N.Y.	2·65
Elwood, Ind.	2·25	Philadelphia, Pa.	1·95
Louisville, Ky.	2·50	Montreal, Canada	3·61½
Chicago, Ill.	2·50		

The Report of the Committee on Canals of the State of New York, appointed by President Roosevelt, as Governor, in 1897, and submitted in 1900, showed that the average rates for the transport of coal on the Chesapeake and Ohio Railroad between 1894 and 1899 were as under, in cents per ton-mile :—

To	1894.	1895.	1896.	1897.	1898.	1899.
Inland Points	·443	·386	·384	·380	·333	·355
Seaboard	·320	·293	·253	·297	·259	·221
Differences ...	·123	·093	·131	·083	·074	·134

These figures are probably the lowest in the history of transportation, unless it be those charged for the transport of coal from Ohio to Lake Superior points, which in 1897 were as low as 29 cents (14½d.) for a distance of between 800 and 900 miles. This latter, of course, was a return freight, and it will probably not be claimed that the figure named had any direct relation to the actual cost of the service. The rate for the transport of iron ore over the same distance, which had been as high as 1 dol. 75 cents (7s. 3½d.) in 1887, fell to 60 cents (2s. 6d.) in 1898, which latter was presumably a remunerative freight.

The rates charged for coal transport on the Chesapeake and Ohio line are exceptionally low. From figures available as to the rates on the Lehigh Valley line,* it appears that the average was

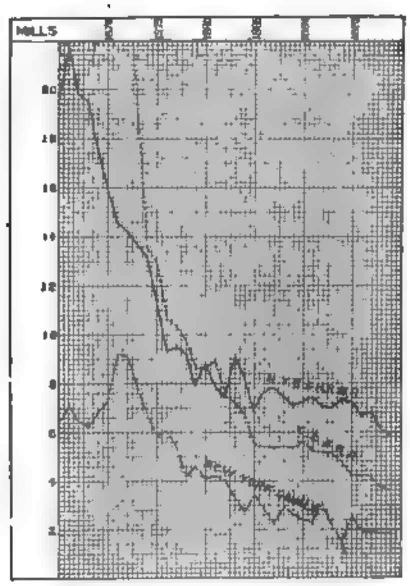


FIG. 25. CHART OF AVERAGE FREIGHT RATES (PER TON-MILE), 1865-1900.

as much as 2 cents per ton-mile in 1871, and that it fell to ·671 cents (or ·335d.) in 1898. On the Philadelphia and Reading line, the average ton-mile rate in 1890 was still over 1 cent, and on the Central of New Jersey it was close on a cent (·959 c.) in 1896. The Pennsylvania Railroad Company and the New York Canals unitedly charged ·882 cents (·441d.) per ton-mile in 1887.

The general movement of ton-mile freight rates in the United States may be followed in the following record of averages in corrected specie values for different dates (in cents per ton-mile):—

* *Changes in the Rate of Charge for Railway and Other Transportation Services*, by H. T. Newcomb.

Railway.	1870.	1880	1890.	1899.
Erie	1·125	836	·643	·52
New York Central	1·590	·879	·730	·59
Lake Shore	1·269	·750	·644	·502
Michigan Central	1·673	·842	·701	597
Pennsylvania	1·268	·918	·661	·561
Pittsburg and Fort Wayne	1·229	·745	·69	·57
Chesapeake and Ohio	4·101	·892	·561	·36
New York Canals	·73	·42	·26	·19

Iron and Steel Rates.—The rates on iron and steel from Pittsburg to the principal ports of shipment are given in the Appendix. It will be noted that to New York, which is by far the most important of the ports used by Pittsburg manufacturers up to the present time, the rates quoted vary from 2 dols. 80 cents (11s. 8d.) per ton of 2,240 lbs., to nearly twice that figure for tinplates; and it will be remarked that the rate for steel rails is higher than that for pig-iron, blooms, or billets.

The rates to Philadelphia are rather under those to New York, but in the cases of blooms, billets, and bars, only 20 cents, or 10d. less, although there is a difference in distance of about 90 miles. The Baltimore rates are less than those of either New York or Philadelphia. The principal rates are as under:—

	New York. Rate per ton-mile.		Philadelphia. Rate per ton-mile.		Baltimore. Rate per ton-mile.	
	In dols.	In pence.	In dols.	In pence.	In dols.	In pence.
Pig-iron	2·20	0·22	2·00	0·23	1·90	·210
Blooms	2·40	0·23	2·20	0·28	2·10	0·28
Billets	2·40	0·23	2·20	0·28	2·20	0·28
Bars...	2·40	0·23	2·20	0·28	No record.	
Rails	2·80	0·28	2·40	0·30	2·30	0·37

The tables furnished by the Commission give a number of rates for long-distance traffic, such as those from St. Louis and Chicago to Denver City, Salt Lake City, and San Francisco, and those from Pittsburg to Pensacola and Mobile.

In January, 1894, Messrs. A. R. Whitney & Co. presented to the Wilson Tariff Committee the following then current freights from the chief manufacturing centres to the sea:—

Average Rates of Freight from—	Per 100 lbs. Dols.		Per ton, 2,240 lbs. Dols.
Pittsburg to Pacific ports	0·48	or	10·75
Pittsburg to Gulf ports...	0·40	or	8·96
Pittsburg to Atlantic ports	0·20	or	4·48
Pittsburg to Pensacola, Fla.	0·50	or	11·20
Pittsburg to New Orleans, La.	0·38	or	8·52
Pittsburg to Charleston, S.C.	0·22	or	4·92
Pittsburg to New York, N.Y.	0·18	or	4·03
Pittsburg to Boston, Mass.	0·20½	or	4·59
	£ s.		
Antwerp and Liverpool to Pacific ports	0 14	or	3·40
Antwerp and Liverpool to Gulf ports	0 10	or	2·44
Antwerp and Liverpool to Atlantic ports	0 5	or	1·25

Since then these rates have been somewhat modified, as we have seen, but, speaking generally, the foregoing figures remain fairly typical, and may usefully be put on record.

The conditions under which traffic is carried on American lines, and notably the Chesapeake and Ohio, which hauls coal traffic with a profit at a trifle over 2 mills, or one-tenth of a penny, per ton-mile, are vastly different. In the case just cited the haul is a long one, extending over several hundred miles. It is one of the most elementary facts in railroad administration that traffic can be carried much more cheaply over long than over short distances. In other words, it is the cost, labour and delay incidental to the handling of traffic that causes the most serious outlay. Hence, when we say that mineral traffic is carried on certain American railroads for one-fifth to one-tenth of the rate charged on British railways, the fact is liable to create an erroneous impression, unless it is accompanied by an explanation of the increase of the cost of working due to short hauls. Even so, however, the difference by increase against the rates charged on British railways is such as provokes feelings of dissatisfaction. It is no comfort to the British trader to be notified that he has to pay higher railway rates than his competitors, because land, Parliamentary expenses, rates and taxes, and other outgoings take a higher range in this country than abroad, however much these facts may control the situation.

While the freight rates charged in the United States for the transport of raw materials are generally very low, it would be a mistake to suppose that all freight rates charged in the United States are equally low. In some cases, American railroad rates are complained of as exceptionally high. This is especially the case with the anthracite coal traffic, which ranges from ½d. to 1½d. per ton-mile.

The following are the quoted rates from Pittsburg to the leading iron and steel manufacturing centres in 1901 :—

RATES FOR PLATES, WIRE, NAILS, AND OTHER FINISHED STEEL FOR SHIPMENT FROM PITTSBURG TO—

	Cents per 100 lbs. Car loads.	Less than Car loads.
New York	13	16
Philadelphia	12	15
Mobile	26	35
Newport News	16	20
West Point...	16	20
Baltimore	11½	14½
Vancouver...	74·2	1·24½
New Glasgow, N.S.	37	44
Pictou	37	44
Quebec	25½	38

Minimum, 30,000 lbs.

Revenue per Ton of Minerals Handled.—In the United Kingdom the total volume of mineral traffic carried in 1900 was over 306 millions of tons, and the total gross revenue therefrom was

£22,870,000, so that the average gross receipts per ton moved were about 1s. 6d. In the United States, for the year 1898, the total tonnage of all freight carried was 879 millions, and the total gross receipts from freight traffic was 875,000,000 dols., so that the average gross revenue per ton moved was just about a dollar. This means that the American average was nearly three times the British average revenue for each ton handled. The difference is, of course, mainly a function of the greater distance carried, which, in the United Kingdom was not more than 35 miles, and in the United States was nearly 120 miles.

This raises the question, often discussed by railway authorities, whether the mere haulage of a train is the most important factor in the cost of transportation, or whether that cost is not rather determined by other elements, and notably by the capital outlay on the enterprise, by the handling of the traffic, by the rate of speed, by the facilities afforded for quick delivery, and by other kindred considerations. These are questions that cannot possibly be dealt with in the space at my disposal, but it may at least be pointed out that they all have an influence, and establish differential conditions which ought not to be ignored.

Heavy American Locomotives.

It is well known that much of the recent progress of the American system of freight transport is attributed to the remarkable increase of weight and power in the locomotives employed for that purpose. In view of this fact, I sought for and obtained permission to go over the Baldwin Locomotive Works, while I also was afforded the opportunity of interviews with several of the partners. I regarded this as all the more important [illegible] of the competition of the locomotive [illegible] in foreign markets, and even in our own [illegible]

The story of the development [illegible] has been succinctly told, in his [illegible] Industrial Commission now sitting in the [illegible] by Mr. George Converse, one of the partners in the [illegible] as follows :—

"The original American locomotive was a [illegible] wheels, and the aggregate weight was probably [illegible] The first change was the addition of the second [illegible] coupling of them together, and the equalisation of [illegible] an American device. Then the next change was in [illegible] wheels together, and the increase in the weight of [illegible] That change occurred during the period 1840 to 1850. In the [illegible] 1850 to 1870, nearly all the existing types of locomotives were [illegible] was some increase in weight. About 1870 the standard [illegible] about 40 tons in weight for an ordinary freight locomotive and [illegible] passenger locomotive. The development has been very great [illegible] and now freight locomotives of 100 tons and passenger [illegible] 80 tons are the rule. All these weights are for the [illegible] of the weight of the tender. The weight of the [illegible] increased, so that, while 40 years ago a 2,000-gallon tender was [illegible] liberal size, tenders of 7,500 gallons capacity are now [illegible]

The influence of this development has been [illegible]

the American locomotive to haul much heavier loads, and it has reduced the cost of motive power relatively to the work performed.

We have seen that the average tons of freight carried in a freight train on the Pittsburg, Bessemer, and Lake Erie Railroad was 868 tons. The average tonnage carried on a British freight train, although not accurately known, is believed to be under 100 tons. The American locomotive, therefore, as typified by the above-named line, probably does nearly nine times the work of a British engine.

Mr. T. N. Ely gave me some interesting figures illustrative of the great advances made on the Pennsylvania Railroad within recent years in providing for the heavier traffic and the greater train loads. Within the last 25 years the tractive power of the consolidation locomotives employed—the type remaining practically the same—has increased from 19,200 lbs., to 39,700 lbs., while the weight of the locomotive, not including tender, has increased from 95,700 lbs. to 193,500 lbs. In the same interval, in order to meet the requirements of heavier trains and locomotives, the permanent way has been increased from 80 to 100 lbs. per yard, and this latter figure is now almost invariably adopted.

To the same authority I am indebted for some information as to the locomotive power at the command of this, the greatest mineral-carrying railroad in the world. In 1901, it directly owned 1,184 freight locomotives, whose tractive power was 28,073,415 lbs., and whose work in 1900 was 40,818,521 miles, the average cost of their repair per 100 miles run in the same year having been 6 dols. 17 cents. The gross earnings of these locomotives in 1900 was 62,171,000 dols., or 52,509 dols. per locomotive.

The fact that a locomotive in the United States is made to do a much larger amount of work than in Great Britain is to a large extent a function of the greater average length of the haul, which is quite three times as much on the other side of the Atlantic, but it is also and mainly owing to the fact that each American freight locomotive is handling from six to ten times the quantity of paying traffic while it is in service. The British railway companies, in other words, have to maintain from five to ten times the number of locomotives to do the same work, and these have to meet the cost of repairs, fuel, train staffs, and other outgoings in proportion. Moreover, the actual first cost of the American locomotive is comparatively low, so that the British system does not seem to guarantee any advantages from this point of view. Mr. Ely informed me that the average value of the locomotives directly owned by the Pennsylvania Company is about 8,000 dollars, or £1,600.

During the last ten years there has been an increase of 25 to 50 per cent. in the capacity of the engines used for mineral traffic in the Pennsylvania mineral region. On the Chesapeake and Ohio road, during that interval, there has been an increase of 12,350 lbs. in the tractive force of the engines employed, or about 33 per cent.* Speaking generally, the locomotive has doubled in weight and power, while its cost has increased by only 50 per cent.

* Paper on "The Large Steel Car," by W. S. Morris, Chesapeake and Ohio Railway. *American Engineer*, Jan., 1901.

Mineral Rolling Stock.

In the United States the great bulk of the railway wagons in use are owned by the railway companies. The Pennsylvania Railroad alone has almost as many cars as all the private traders put together. Demurrage is charged at the rate of a dollar for 24 hours, if a car is held at any station for more than 48 hours, but this rule is not very rigidly enforced. Terminal arrangements are usually rather favourable to the trader. They are not charged for as terminals, but as switching charges, and they vary from 1 to 12 dols. per car. In the case of using private cars on public railways, the railway company pays to the trader from $\frac{3}{5}$ cent to $\frac{3}{4}$ cent per mile travelled by the car, for its use, in lieu of that of their own car. The trader in such cases is also paid on return empties. There is some talk of converting this allowance into a per diem arrangement. Loading and unloading is usually done by the consignor. Rates can be reduced without previous notice, but when advanced ten days' notice is required. The reasonableness of a rate is difficult to determine, an equal number of men being usually ready to declare that it is and that it is not so.

In the company of my colleagues, I was afforded the opportunity of being shown over the important works of the Schoen Pressed Steel Car Company, in the neighbourhood of Pittsburg, and of witnessing a system and rate of production of rolling stock, specially designed for mineral traffic, which has no parallel in any part of the world. This company has four works—at Allegheny, at Pittsburg, at McKees Rocks, and at Joliet. It was founded by the engineer whose name it bears for the purpose of manufacturing all-steel cars adapted to every kind of freight traffic, but more especially minerals, of new design and of large capacity.

This company, which is taken as being both typical and the largest of its kind—for other concerns now carry on the business quite extensively—was able to satisfy the American railroads that by the adoption of its system there was a less number of cars required, a reduced empty car movement, and reduced friction and atmospheric resistance, train length, switching service, number of car parts, and smaller payment for car mileage and for the cost of inspection, which is usual in the United States. It is also claimed that the steel car reduces the repairs from 35 to 40 dols. per annum for wooden cars, to between 10 and 15 dols. for the company's system, while the car has greater life, gives greater salvage, and entails no insurance.

An example of what has thus been achieved in the cheapening of American transport may be quoted. On the B. and O. Railroad 50 cars, each weighing 34,000 lbs., were loaded with an average of 98,000 lbs. of coal, the train being computed to weigh 6,458,100 lbs. gross, while the net weight of coal carried was 4,758,000 lbs. This infers a tare of only 26 per cent., and a total load of nearly 3,000 tons. Within the last few years, by the substitution of pressed steel cars of 110,000 lbs. for wooden cars of 60,000 lbs., in mineral traffic, the ratio of load to total weight of car when loaded has been raised from 66·67 per cent. to 79·13 per cent.

From 50 to 60 per cent. of the Lake Superior ores are forwarded in cars direct from the vessels at the head of Lake Erie to the fur-

naces in Pittsburg, etc., without first being stored at the docks. These vessels a few years ago were of a maximum capacity of from 2,500 to 3,000 tons; now they carry as much as 8,500 tons. A quick despatch is required on the part of the vessel owner, which, under conditions prevailing five years ago, would be impossible, but by the use of the 100,000-lb. capacity car it has been accomplished. The railroad companies are handling a much heavier tonnage over the same tracks, and, notwithstanding the earnings per ton-mile have been greatly cut down, they have been able to maintain a margin of profit.

A careful record taken of nearly 200,000 cars handled on two lines of railway leading from Pittsburg to two of the principal ports of Lake Erie shows that it was possible to secure the following loads for their cars:—

Ore, 108 per cent. of marked capacity.
Coal, 82 per cent. of marked capacity.
3,616 of the 100,000-lb. capacity cars showed an average lading carried of 93 per cent.
136 of the 70,000-lb. capacity cars showed an average lading carried of 91 per cent.
6,727 of the 70,000-lb. capacity cars showed an average lading carried of 97 per cent.

The advantages gained by reducing the length of the train for a given tonnage, which are secured by the use of large capacity cars, are stated to be:—

First.—The friction and atmospheric resistance are lessened, and by bringing the moving load closer to the locomotive it can be handled with greater ease.

Second.—A less number of cars and locomotives are required to move a given tonnage, saving interest on capital and car service, and lessening the empty car movement in the direction contrary to the heavy traffic movement.

Third.—The necessity of increasing the capacity of the main lines, freight yards and shops is avoided, and at the same time the cost of switching is reduced.

Fourth.—A large saving in wages results from the decreased number of trains.*

In the early history of the American freight car, about 7,000 lbs. and four wheels were considered the proper "goods wagon." Coal cars in 1860 carried five tons, and merchandise cars were built to carry about the same weight. As late as 1865, 15,000 lbs. was considered an ordinary load for a box car. In 1874, box cars were introduced, the weight of which was about 19,000 lbs. and their capacity 14 tons. The 20-ton car was introduced in 1876; the 25-ton in 1883, and the 30-ton car in 1885. In 1895 the 40-ton car was adopted. To-day, the 50-ton car, made of steel, carrying 10 per cent. above its marked capacity, the tare being less than 25 per cent. of the total weight of the car and lading, is the form generally in request.

Mr. Twinberrow recently informed the Inst.C.E. that "so long as the present light trains, with large proportions of dead weight,

* W. S. Morris on "The Large Steel Car."

and costly repairs and renewals, prevail, so long will English railways find it impossible to handle heavy freight in volume at low rates," but, as the regulations of the Railway Clearing House have hitherto practically confined them to the use of 10-ton wagons, reform has been difficult. On the North-Eastern Railway two types of wagons have lately been experimentally adopted, which promise to go some way to solve the difficulty—simplicity being studied in the employment of standard rolling mill shapes and flat plates, with very little smith work.

Foreclosures and Receiverships of American Railroads.

The low freight rates charged on the railways of the United States have been blamed for the fact that so many of the lines have had to go into liquidation, and no doubt there is a *primâ facie* case to justify this assumption. In the 25 years ending with, and including, 1900, 634 roads, representing 113,275 miles of line, and a total capital in bonds and stocks of 6,388¾ million dollars, went into the hands of receivers. In the black year, 1893, alone, 74 roads, with a total of 29,340 miles, and bonds and stocks aggregating 1,781 million dollars, were so dealt with. Even in the prosperous year, 1900, 3,477 miles of railroad were sold under foreclosure, the total bonds and stock of which were in excess of 190½ million dollars.

This is a gloomy record, but it is not necessarily the result of low railway rates, although it is admittedly to a large extent due to unrestricted competition. The railroads of the United States are, however, built in advance of both population and traffic, and it depends largely on their staying powers whether they can be kept alive until they become self-supporting. The Pennsylvania Railroad, which quotes among the lowest rates known, even in the United States, has long been a prosperous enterprise, and has demonstrated the possible co-existence of low rates and good dividends.

B.—AMERICAN LAKE TRANSPORTATION.

The conditions of the American iron industry are greatly affected by the very remarkable system of water transportation of Lake Superior ores from the ports of shipment to Cleveland, to Buffalo, and to Chicago. This is now the cheapest transportation of its kind in the world, and it has such an important bearing on the whole question of American costs, past, present and future, that it calls for a rather full statement of the facts.

Briefly, the essential fact is that the iron ore mined in the Lake Superior ranges is transported over a thousand miles to the blast furnaces of Pennsylvania, Ohio, New York, and Illinois, at a cost of about 1½ dols., or 6s. 3d. per ton, including two railway journeys, ranging from 50 to 180 miles, and two breakages of bulk.

The last 20 years has witnessed a reduction of lake transport alone, varying from 750 to 900 miles, from a contract rate of 2 dols. 45 cents (10s. 1½d.) in 1881, to an average of 60 cents (2s. 6d.) per ton in the two years 1898 and 1899. The latter rate from Escanaba, however, was as low as 45 cents (1s. 10½d.) in each of the two years 1897

and 1898. This is plus a charge for trimming and unloading of 25 cents (1s. 0½d.) per ton.

The cars used to transport the ore from the mines to the lakes are usually of 25-ton capacity, and are run in trains of about 40 cars each. These trains follow one another at intervals of half an hour on some of the roads, thus enabling the line, when worked to the limit of its capacity, to transport fully 1,000,000 tons of ore per month. The movement of ore by these roads during the seven or eight months of the year during which navigation is open on the lakes is said to constitute, in proportion to the trackage, the heaviest traffic ever handled on any railroad in the world. Upon arrival at the point of transference from rail to vessel, the ore trains are run out upon one of the four tracks which traverse the top of the trestle-like structure that constitutes the loading dock. The ore is then allowed to escape through hoppers in the bottoms of the cars directly into the bins or pockets of which the ore dock is made up.

There are 21 of these docks located at five different ports on Lake Superior, and two on Lake Michigan. At each port there are from one to five docks. The docks themselves range from 500 to 2,500 feet in length. All the docks combined have more than 5,000 pockets, and are capable of storing somewhere near 830,000 tons of ore at one time. Attached to the dock, directly in front of each pocket, is an adjustable chute, through which the ore slides directly into the hold of a vessel. The lake vessels have numerous hatches, so that it is possible to load from several different pockets simultaneously, and it is not uncommon to have a full cargo placed aboard one of the largest vessels on the Great Lakes in the space of only three or four hours.

Vessels Employed on Lake Traffic.

The great majority of the vessels employed in this trade have been built with special reference to their requirements. They have usually rounded ends, and are unprovided with a deck on the main deck beams in the cargo holds. At the extreme forward end of the boat are the bridge, mast, and deck-house, while the propelling machinery is crowded as far aft as possible, an arrangement resorted to in order to provide the greatest possible number of hatches through the central portion of the boat.

The fleet of ore-carrying vessels is divided between steamers and barges, the latter designed to be towed by the former. The steamers can, by the utilisation of improved steam towing machines, tow one, and frequently two, of these barges, and on occasions upwards of 20,000 tons of ore have been moved the whole distance down the lakes by one engine, the entire trip being made at an average of 13 miles per hour.

The steel steamer *Matoa*, of the Minnesota Steamship Company's fleet, represented in 1890 the largest type of carrier on the Great Lakes. Her registered tonnage, gross, is 2,311, and she is 290 ft. long, 40 ft. beam, and 21 ft. depth of hold. The draught of water through connecting channels of the lakes in 1890 averaged 15 ft. 6 in., and on that draught the *Matoa's* average cargo of ore was about 2,500 gross tons. The average loading time at upper lake ports for such a vessel

as the *Matoa* in 1890 was about 15 hours, and the average time at Lake Erie ports, unloading, about 36 hours.

The *John W. Gates* is one of the largest type of lake freighters to-day. The *J. J. Hill*, *William Edenborn*, and *Isaac L. Elwood* are vessels that are in all respects similar to the *Gates*. The *Gates* is about 500 ft. length. Her beam is 52 ft., depth of hold 30 ft., and gross tonnage 5,085. Her average cargo is practically 7,000 gross tons on a draught of 17 ft. 10 in., the loading time is 15 to 26 hours, and the average unloading time about 43 hours.

Work done by Vessels.—In the season of 1900, 357 vessels engaged in the lake ore trade, each in a single trip only, carried a total of 1,422,000 tons; one vessel, the *John W. Gates*, carried 8,462 tons as a single cargo. Another, the *Presque Isle*, carried 195,550 tons in the course of the season; another, the *Troy*, ran 45,318 tons during the season; while another, again the *John W. Gates*, made in the same period over 154½ million ton-miles. In one single day of 1900, 219,364 freight tons were loaded into 127 vessels at Lake Superior ports.

Up to 1884, the tonnage of sailing ships on the Great Lakes was greater than that of steamers. Four years later the relative proportion of steamers had greatly increased, having taken a leap of 90,000 tons, or more than 23 per cent., in a single year. By 1890, the steamers had reached a tonnage twice as great as that of the sailers, and by 1898, they had further increased to just about three to one. Meanwhile, the size of the vessels employed in both categories had greatly increased. Between 1888 and 1898, the average capacity of steamers on the lakes had grown from 350 to 560 tons, and there had been an almost corresponding increase of size in the sailing ships employed, the average of which, however, was materially less.

Lake Freight Rates.—In the statistical monthly summaries, issued by the United States Government in 1901, some interesting information is given as to lake rates (p. 1745), from which it appears that in the ten years ended 1900, the average daily freight rates were, per gross ton:—

90 cents	from head of Lake Superior	to Ohio ports.
79 „	„ Marquette to	„
64½ „	„ Escanaba to	„

against corresponding averages, for 1898, of 50·8 cents, 61·0 cents, and 59·8 cents.

The ten-yearly averages for the transport of coal from Ohio ports to Lake Superior ports for the same periods were, in cents:—

Ohio Ports to	Average of 10 years.	Average of 1898.	Average of 1900.
Duluth ...	... 37 ...	... 23·4 ...	... 40·2
Milwaukee	... 47 ...	... 27·8 ...	... 45·4
Escanaba ...	... — ...	... 26·4 ...	... 40·0

The variations to which lake freights are subject appear in the foregoing figures.

Cost of Water Transport.

"The report of Governor Roosevelt's Committee on the New York State Canals has the following remarks on the cost of water transport :—

"The possibilities of water navigation are illustrated by the rates prevailing on the Great Lakes. The average rate on all traffic through the St. Mary's Falls Canal in 1898 was ·79 mill (about one twenty-fifth of a penny) per ton-mile. This includes some proportion of high grade package freight ; and on the bulk commodities the rates are still lower. The average rate on wheat from Duluth to Buffalo in 1898 was 2 cents per bushel, and from Chicago to Buffalo 1·5 per bushel, equal to ⅔ of a mill (one-thirtieth of a penny) per ton-mile. The rate on iron ore from Lake Superior to Ohio ports was 60 cents a ton or ¼ mill (one-eightieth part of a penny) per ton-mile. Grain, ore, and lumber form the east-bound traffic on the lakes ; for west-bound ships the most important freight is coal, which is carried at rates much lower than those mentioned, averaging in 1898 from 25 to 30 cents per ton for the entire distance from Ohio ports to Duluth, or ·25 to ·3 mills per ton-mile.

"Long-distance freights on the ocean are as low, and in some cases lower, than rates on the lakes. Between Havre and New York (3,596 miles) the wheat rate, with of course variations, is about 3·00 dols. per ton, or ·84 mills ($\frac{1}{24}$ d.) ; but from New Orleans to Havre (5,332 miles) the rate is 3·40 dols. per ton, or ·64 mills ($\frac{1}{31}$d). Coal is carried between Havre and Valparaiso (9,920 miles) for 3·67 dols. per ton, or ·37 mills ($\frac{1}{57}$d.). Wheat is carried from San Francisco to Europe (15,500 miles) for 5·00 dols. per ton, or about ·3 mills ($\frac{1}{88}$d.). English coal on return trips is carried for 3·20 dols. per ton, or ·2 mills ($\frac{1}{160}$d.). Wheat from Bombay to Marseilles is carried for an average rate of 3·50 dols. per ton, and coal from Cardiff to Bombay (6,273 miles) at 2·90 dols. per ton, or ·46 mills ($\frac{1}{43}$d.) Wheat is carried from Bombay to London and Continental ports for 3·60 dols. per ton, or ·6 mills ($\frac{1}{33}$d.)."*

The lake freight is, however, subject at times to violent fluctuation, as will be seen from the following table, from which it appears that in 1899, the average daily rates of freight within twelve months increased by more than 100 per cent.

AVERAGE DAILY RATES OF FREIGHT ON THE GREAT LAKES, PER GROSS TON.

	1898. Cents.	1899. Cents.	1900 Cents.
Iron ore :			
Escanaba to Ohio ports...	50·8	94·8	69·5
Head of Lake Superior to Ohio ports...	61·0	129·5	84·5
Marquette to Ohio ports	59·8	108·5	78·3

A recent United States Government Report has the following additional remarks on this subject :—

"The low cost of moving freight on the Great Lakes has been one of the prime factors in attracting attention to the economic advantages of this transportation route. At no time have the railroads been enabled to carry raw material between the upper and lower lake ports or *vice versa* at rates less than double those made by the vessel men—that is, with a season's average taken as a basis for comparison, and

* *Ocean Freight Rates*, by R. L. Corthell.

during a majority of the years comprising the closing decade of the century, the average cost of moving a ton of freight a mile by lake vessel ranged from one-third to one-fourth the tariff for similar service on either one of the two leading trunk-line railways paralleling the Great Lakes.

"Carrying charges on the Great Lakes have fluctuated to such an extent from year to year that it is only by comparing the rates which have prevailed during a period of years that an adequate idea of transportation costs may be gained. Thus in 1900 average lake freight rates were higher than in 1896, 1897, or 1898, not because of any unusual amount of freight to be moved, but by reason of the fact that such was the expectation of a phenomenal demand for tonnage that charters for vessels were entered into months before the opening of the season, at prices which were greatly in excess of those which prevailed in the open market later. For instance, whereas ore-carrying contracts were made near the close of 1899, covering the entire navigation season of 1900, on the basis of 1·25 dols. a ton for a haul from the ports at the head of Lake Superior to ports on the south shore of Lake Erie, the 'wild' or daily rate which prevailed after the vessels went into commission averaged less than 85 cents per ton. However, as has been stated, the prices at which season contracts were made were sufficient to bring the average rate from each port above the figure prevailing during the three years previous."

During my sojourn at Philadelphia I had the opportunity of an interesting conversation with Mr. F. J. Firth, manager of the Erie and Western Transportation Company, who is an authority on the water communications between the Great Lakes and the sea-board. "It is hardly 30 years," he said, "since it was unusual to have a vessel carrying 1,000 tons of minerals on the Great Lakes, whereas now 7,000 to 8,000 tons is the capacity provided for in new craft." In New York State it has been proposed to deepen the Erie canal from Buffalo to the navigable waters of the Hudson, so that it shall be possible to take through barges capable of carrying 1,000 tons.

From what Mr. Firth said, I gathered that one of the most important transportation movements of the present and the future is that promoted by the National Rivers and Harbours Congress, which is an annual gathering of representatives of the various industrial centres interested in cheap freights, and which aims at having the physical conditions of lakes, rivers, canals, and other waterways so improved as to cheapen and facilitate the conditions under which heavy traffic is carried, in competition with railway transport.

In Mr. Firth's opinion, the terminal facilities at the leading British ports are not nearly so good as the arrangements made for the handling of traffic at such ports as Cleveland and Conneaut, on Lake Erie. In proof of this he declared that he knew of no case in England where there were, as at Conneaut, hydraulic lifts that would pick up 10 tons at each lift from the vessel's hold, and in three minutes deposit it in a car alongside. I did not argue the point, although I am well aware that Sir William Lewis could have given a very good account of the facilities provided at Cardiff, and Mr. George Gibb of those at Tyne Dock, for similar operations.

C.—RIVER TRANSPORTATION.

Hitherto, with their immense system of lakes, their considerable system of canals, and their universal system of cheap railroad transport, the opportunities for using river transport have not been utilised to anything like the extent that might have been expected in the United States, except where coal traffic is carried on the Ohio, Mississippi, or other rivers for the supply of towns on the route. But there is good cause to suppose that in the not distant future, river transport will play a much more important part in the industrial development of that country than it has yet done, and not least so in the southern States. There the Kanawha River has already been considerably improved, and arrangements are now being made to utilise more effectively the Coosa River, with a view to getting cheaper access to the sea.

The feasibility and necessity of connecting the waters of the Tennessee River with those of the Gulf of Mexico, by utilising the Warrior or Coosa and Alabama Rivers, had for years been the subject of discussion both in Tennessee and in Alabama. In 1875 the War Department caused Major McFarland to make a survey of a route from near Guntersville on the Tennessee to a point near Gadsden on the Coosa. Another survey was made in 1898, by Mr. Joseph Ripley, an expert on waterways, who had something to do with the project from his connection with the Sault Ste. Marie Canal, and whose report came as a revelation even to those who for years had hoped and believed in a general way that the project was feasible and practicable. The erection of locks and dams was suggested, and the scheme was recommended as a matter of the greatest national importance. The Secretary of War approved this report, and in his Annual Report to Congress in 1899, recommended that the work be done. Its importance has attracted widespread attention not only in the south, but in the financial centres of the east and among manufacturers all over America, who believe it is wise and far-sighted to help southern coal, iron and steel to go abroad, leaving largely the home markets to the northern and eastern manufacturer and producer.

Mr. James Bowron, of the Tennessee Coal, Iron and Railroad Company, whom I had the pleasure to meet in Birmingham (Ala.), stated, in July, 1900, that the Government Engineer had estimated the cost of transportation of coal and iron by the Warrior River and the slack water navigation, thence to Birmingham, as one-fourth the cost of its transportation by rail, or say $\frac{1}{20}$d. per ton per mile, as against an average rate of $\frac{1}{5}$d. per ton per mile. Prior to the expansion in prices of iron in 1900, the export movement from the Birmingham district had attained a volume of over 200,000 tons per annum. Allowing 50 cents from Birmingham to Mobile as the cost of transportation, Mr. Bowron expressed the opinion that this volume of export shipments of iron and steel products could be doubled if 50 cents per ton could be saved in the transportation from Alabama to the Gulf, and, moreover, that in addition to the present limited export trade in coal, with such a saving a million tons per annum could be added to export sales of coal. He also thought it certain that, with the completion of this canal and transportation at 50 cents to Mobile, Birmingham

district would have control of the coal trade available on the Pacific coast between San Francisco and Valparaiso, after the construction of an isthmian canal, as it would be able to place steam coal f.o.b. at Mobile at a lower price than similar coal costs to-day f.o.b. ship at English ports.

These are possibly only dreams, but the dreams of American pioneers have a habit of being fulfilled, and there is a considerable amount of enterprise and determination at the back of the proposal to give Alabama and one or two other southern States access to the sea at a less rate than many districts of Great Britain, and at one-fourth of the rates that the freighters of the other and greater Birmingham have to pay, although only about one-third of the distance.

D.—CANAL TRANSPORTATION.

The interest which is being taken in the United States, and especially in the State of New York, on the conditions of the improvement and fuller employment of canals and other waterways as a check on railway charges, suggests the old question of whether it would not be possible, by a similar movement, to help the coal and iron trades of the United Kingdom. It would be out of place to do more than merely make the suggestion here, owing to the magnitude of the issues involved; but I may at least point out that in several able letters published in the *Manchester Guardian* in 1901 and 1902, Mr. George Cawley, of Westminster, consulting engineer to the Japanese Government Railways, points out that at present the expenditure on our canal system as a whole is about 70 per cent. of the receipts; that the average cargo per boat is not more than 40 tons; that horses are still generally engaged in haulage at a quite unnecessarily high cost; that if the canal companies had their boats hauled electrically, no difficulty need occur in using any size of boat within the limits of any given canal; and that haulage of either large or small boats could be carried out at approximately half the present cost. Surely this is a matter deserving the consideration of the British trader.

According to a Report recently issued by the New York Chamber of Commerce, the rates "charged on high-grade traffic from New York to Chicago are from 5·1 to 15·3 mills ($\frac{1}{4}$d. to $\frac{3}{4}$d.) per ton-mile; while on the shorter hauls to New York State points, the sixth-class rate is from 6 to 12·5 mills ($\frac{1}{3}$d. to $\frac{2}{3}$d.) per ton-mile, and the first-class rate from 17·7 to 31 mills (·88d. to 1·55d.).

"At present railroads carry most of this high-class freight in the face of much lower canal rates, on account of their better facilities for handling and delivering package goods—due in part to advantages inherent in the railroad, and in part to the advantages of large corporations over the small canal-boat owners. Nevertheless, the potential competition of the canals secures lower rates for this traffic than exist where there is no canal competition possible. The rates on high grade freight from New York to competitive railroad points in Pennsylvania are from 10 per cent. to 35 per cent. higher than to points on the canals a corresponding distance from New York. Buffalo and Pittsburg are at almost equal distances by rail from New York; yet

the rates are to Buffalo on sixth-class goods 13 cents, to Pittsburg 15 cents per 100 lbs.; on first-class goods, rates to Buffalo are 39 cents, to Pittsburg 45 cents per 100 lbs. Similar differences exist in the rates to Albany, Utica, Rome, Syracuse, and Rochester, as compared with those of Reading, Wilkesbarre, Harrisburg, and Altoona, the only explanation of which is the existence of the canal route across New York State."

E.—OCEAN FREIGHTS.

Mr. C. M. Schwab informed us that quite recently the Carnegie Works had shipped steel from New York to Glasgow at 9s. per ton, and billets from New York to Liverpool at 6s. 6d. per ton, while plates had been shipped to Belfast, including transhipment, at 18s. per ton. These freights had enabled them to deliver billets in Birmingham at 18½ dols. (£3 17s. 2d.) per ton. From other sources I learned that Valley iron (made within 60 miles of Pittsburg) had been landed at Liverpool for less than 12s. per ton, including freight to tide-water, while a good deal of the iron made in Alabama has been carried across the ocean at exceedingly low rates of freight, down to 3s. to 5s. per ton, but in such cases the iron has been treated as ballast. It is almost certain that the future of ocean freights will be affected by the recent combination, or so-called conference, of Atlantic shipping companies. The statement is made that these companies have agreed to raise freight rates all round from 20 per cent. to 40 per cent. Of course, the ocean tramp will still be available, and, being outside the conference, will probably cut conference rates, but there is no likely need for him to make substantial cuts in order to get business, and a shipping conference has an awkward way of getting shippers in their power by a system of rebates, of which a large part is kept in hand, and is given conditionally on the trader shipping all his consignments by a particular line.

SECTION VI.

CHAPTER IX.

The Costs of Producing Iron and Steel in the United States.

Pig-Iron.

THERE is no matter affecting the production of iron and steel, or, indeed, of any other product, in respect of which there is so much liability to confusion and error as the cost of manufacture. The costs of one period are not those of another. No two districts have precisely the same range of costs. Probably there are hardly any two works that will show the same cost-sheets. The conditions that affect the variations of cost of manufacture differ from day to day, so that nearly all attempts to fix definite data on this matter are more or less elusive. And yet the ascertainment of such costs is fundamental in any inquiry into the comparative and competitive circumstances of national industries.

What, again, is the true and permanent basis of such an inquiry? In the United States there is naturally a considerable difference between the cost at which a concern like the Steel Corporation can produce and sell its finished products, and that of the rival enterprises that are not similarly situated in relation to supplies of raw material, labour, facilities of transport, and other essential conditions. The enterprise that is founded on ample supplies of cheap raw material, is likely, other things being equal, to produce more cheaply than its rival, which has to purchase its raw material in the open market. The former can rely on more or less stable conditions of cost. The latter is liable to great variations of cost from time to time, following on fluctuations in current market values.

As, however, the majority of the iron and steel manufacturing concerns in the United States possess their own mines and quarries, and are thus more or less independent of outside supplies, it will probably be better, in dealing with costs of production, to assume the command of the necessary raw materials at prime cost.

The Assemblage of Materials.

It is of interest to recall the fact that in the year 1876 Sir Lowthian Bell made a Report on the Centennial Exhibition at Philadelphia, which had a certain amount of vogue at that time, in the course of which he computed the cost of assembling the raw materials

per ton of pig-iron at the blast furnaces of the principal iron-making districts at the following figures :—

	Coal.	Iron Ore.	Limestone.	Total.
	£ s. d.	£ s. d.	s. d.	£ s. d.
Pittsburg ...	0 3 9	1 10 0	1 6	1 15 3
Cleveland ...	0 11 9	1 2 6	1 9	1 16 0
Chicago ...	1 3 0	1 2 0	1 6	2 6 6
Alabama ...	0 3 0	0 5 0	1 6	0 9 6
Lehigh Valley ...	0 8 2	0 12 0	1 0	1 1 2
Harrisburg ...	0 10 2	0 10 0	0 9	1 0 11

In every one of these cases, except Alabama, the cost of assemblage of raw materials was greater in the United States than in any district of Great Britain.

In the same Report it is stated that the cost of Lake Superior iron ore at the mine was then 15s. to 17s. per ton, that the largest quantity of ore obtained in any one year was a little over a million tons, and that, "there are those in the district who say not only that this cannot be exceeded, but that unless fresh discoveries are made there will be a sensible diminution in a very few years of the first-class ores."

Some of the iron-masters of that time, who deemed a million tons a year to be the maximum output of the Lake Superior mines, have lived to see those mines produce more than 20 million tons a year, but, of course, under very different general conditions.

A glance at the section of this Report which deals with transportation will show how enormously the conditions have changed in the interval—so much so, that the total cost of producing pig-iron is now in probably a good many cases, and certainly in some, less than the cost of assembling the materials alone at the time when the above estimates were framed.

Progress between 1880 and 1890.

For the purpose of carrying this matter a little farther I have examined the Census Reports on the iron industry of the United States for each of the years 1880 and 1890. An analysis of the figures there published shows that the average cost of iron ore at blast furnaces, taking the country as a whole, was 4·6 dols. in 1880, and 3·7 dols. in 1890, whereas it is not more than 3 dols. at the present time; that the average yield was 48·86 per cent. of iron in 1880 and 54·36 per cent. in 1890; that the wages paid per ton of pig made in Pennsylvania were 2·4 dols. in 1880 and 1·5 dols. in 1890, while the average output per employé was 143 tons and 304 tons; that in the same State the average total cost of materials per ton of pig was 15·5 dols. and 11·1 dols.; and that the average quantity of bituminous coal and coke used per ton of coke pig in the country generally was 2 tons in 1880, and 1·4 tons in 1890.

Records of 1889.

In 1889, Colonel Wright published the following averages of eleven plants producing Bessemer pig-iron in the United States :—

AVERAGE RAW MATERIALS CONSUMED PER GROSS TON OF PIG-IRON, IN CWTS.

Ore.	Cinder and Scrap.	Limestone.	Coke.
31·36	1·55	10·33	23·67

At the same time the cost per ton of pig-iron worked out, on an average of the eleven plants, to the following figures :—

Ore.	Cinder and Scrap.	Limestone.	Coke.	Labour.	Other Charges.
s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
38 7¾	0 10¼	2 1¾	13 5¼	5 10¼	3 4¾

Since these figures were applicable to the making of Bessemer pig there has been a notable reduction in every item, but chiefly in the item of iron ore, due to the subsequent discovery of the Mesaba range deposits; in coke consumption, which in the best practice has fallen to about 17 cwt.; and in labour, which has in some cases been reduced to less than 2s. per ton of pig.

Twelve years ago, it was ascertained by the same statistical authority, that the cost of transport per ton of Bessemer pig in eleven establishments in the United States was 23s. 11·4d. (disregarding fractional items of coal), made up as follows :—

Description.	Average Distance. Miles.	Average Rate per ton. s. d.	Total Transport. s. d.
Iron Ores ...	853	10 6	16 4·6
Coke	113·2	5 4½	6 4·3
Limestone ...	86·8	2 4	1 2·5

It will be noted that at this time the average ton-mile rates over the whole were :—

0·14d. for iron ores,
0·53d. for coke, and
0·32d. for limestone.

The Pittsburg District—Past and Present.

In his Report on the American iron trade prepared for the special volume dedicated to the visit of the Iron and Steel Institute to the United States in 1890, Sir Lowthian Bell gives the following details of the cost of producing Bessemer pig in Pittsburg and Great Britain (West Cumberland) at that time :—

	Pittsburg.		£	s.	d.	West Cumberland.		£	s.	d.
Materials.										
Ore	35·8 cwt.,	6/6	0	11	7¾	... 37·11 cwt.	8/- ...	0	14	10
Coke	21 „	7/9·3	0	8	2	... 21·00 „	8/11½	0	9	4¾
Limestone	10 „	1/4·5	0	0	8¼	... 10·00 „	1/10½	0	0	11¼
			1	0	6			1	5	2
Transport.										
Ore, Lake Superior	35·8 cwt.,	10/1½	0	18	2	... 37·11 cwt.	1/2 ...	0	2	2
Coke	21 „	5/3	0	5	6	... 21·00 „	7/3¼	0	7	7¾
Limestone... ...	10 „	1/8	0	0	10	... 10·00 „	1/- ...	0	0	6
			1	4	6			0	10	3¾
Labour	...	...	0	5	9	... ...	... ...	0	2	9
Other Charges ...	...	...	0	3	0	... ...	... ...	0	2	0½
	Total	...	2	13	9		Total ...	2	0	3¼

It will be observed that the transport of materials amounted in the case of the Pittsburg furnaces to 45 per cent. and in the case of the West Cumberland furnaces to 25 per cent. of the whole cost.

During the comparatively short interval that has elapsed since these figures illustrated the comparative conditions of the two countries, great changes have taken place. I have already fully referred to the discovery of the Mesaba range of iron ores on Lake Superior, whereby vast supplies of probably the cheapest ores in the world are placed at the disposal of the Pittsburg iron-master, at a cost which is variously stated to range from 1s. to 2s. 6d. per ton at the mine. Improvements in methods and plant have enabled the consumption of coke to be reduced from 21 cwt. per ton of pig to between 17½ and 18 cwt. in the best practice, and the transport of ore from the mines to the furnaces, instead of being 10s. 1½d. per ton, has been reduced to little more than half of that figure. Not only so, but the cost of labour at the furnaces has fallen in the best practice to an average of not more than 2s. per ton, and the cost of coke at the ovens had in the interval fallen to about a dollar a ton, against almost double that figure in the above statement. On the other hand, in the English hematite district the tendency of the cost of ore has been to increase. The average price of the last three years has been between 12s. and 14s. instead of 8s. per ton at the mine, while the average cost of coke at the ovens in South Durham has been nearer 14s. than the 8s. 11½d. estimated in the above figures.

For purposes of comparison it is of advantage to select a more normal year than 1900, and the beginning of 1899 may be taken as such a period. Mr. Kirchhoff's figures show that, comparing the years 1890 and 1899, and taking the former year as a unit of 100, the following differences have taken place in the pig-iron costs of a typical blast furnace plant in the State of Pennsylvania :—

	1890.	1899.
Product per day, tons	100	163·3
Fuel per ton of iron, lbs.	100	97·0
Ore per ton of iron, yield	100	103·7
Limestone ditto, lbs.	100	74·5
Wages for labour	100	61·1
Incidental and office expenses	100	70·6
Average price of pig, at furnace	100	62·2
Total cost per ton of iron	100	65·8
Net profit...	100	33·9

From these figures it will be noted that in the interval the price of the product had declined by about 38 per cent.; the net profit had declined by 66 per cent.; the cost of labour by about 39 per cent.; and the total cost of the product had declined by 34 per cent.

Again, Mr. Kirchhoff has submitted the following figures as to percentage reductions of pig-iron costs between 1889 and 1898 from another source :—

	1889.	1898.
Limestone	100	40·3
Coke	100	64·1
Labour	100	51·9
Sundries	100	33·4
Total cost	100	63·4
Average selling price	100	61·2
Net average profit	100	47·9

Here we find that in the period 1889-98, the cost of ore had fallen about 21 per cent.; of limestone, about 60 per cent.; of coke, about 36 per cent.; of labour, about 48 per cent.; and of sundries, about 66 per cent.; while the total cost fell from 100 to 63·4 per cent. No similar reductions of cost have been achieved in any other country, and certainly not in England, where the cost of production has rather tended to increase.

Existing Pittsburg Conditions.

Early in 1899, Mr. Jeremiah and Mr. Archibald Potter Head presented to the Institution of Civil Engineers a paper* in which they computed the cost of Bessemer pig-iron at Pittsburg at 32s. 5½d., and that of iron on Tees-side at 52s. 2d. per ton, showing a difference of almost 20s. per ton against the North of England. These figures naturally attracted much attention, and excited in certain quarters a certain amount of alarm. In the course of the discussion on this paper, I spoke on the conditions involved in these figures that were liable to fluctuate from time to time, and their consequent want of finality.

Since then much has happened. Messrs. Head gave the cost of Lake Superior ore at Pittsburg at 12s. 8d. per ton, whereas over the last two years its average quoted price has been 30 per cent. more than that figure. They gave the then price of coke at works as 7s. per ton, whereas for the last two years it has averaged between 9s. and 10s., and so, *mutatis mutandis*, with other items of cost. On the other hand, it is not probable that British conditions have in the interval improved in any material degree. The costs of 1899 remain substantially the costs of to-day, except in so far as they may have been modified by reductions in the quantity of coke consumed or the labour paid per unit of output.

The present cost of materials for Pittsburg Bessemer iron, and the approximate average of the last three years, will probably be near to the following mark :—

			s.	d.	s.	d.
Mesaba Ore	36 cwt.	at	14	4	25	0
Coke	20 „	„	8	4	8	4
Limestone	10 „	„	1	4	0	8
Total cost of Materials					34	0

In these figures I have adopted the prices at which Mesaba Bessemer ores—the cheapest in the United States of their kind—have been sold upon season contracts at Cleveland in the three years ended 1901, as recorded by Mr. Swank, of the American Iron and Steel Association, in his admirable statistical reports, and I have taken the price of coke on cars at ovens at the end of 1901, as recorded by the same authority. To the figures just quoted the transportation charges to be added for assemblage at blast furnaces are—

Iron Ore, Cleveland to Pittsburg or Valley	at 4s. 6d.	per ton.
Coke, Connellsville to „ „	„ 3s.	„
Limestone, quarries to „ „	„ 10d.	„

* "The Lake Superior Iron Ore Mines, and their Influence upon the Production of Iron and Steel." "Proceedings," Part III.; vol. 137.

making a total of about 11s. per ton of pig-iron, and bringing up the total cost of materials at furnaces to about 45s. per ton, in cases where raw materials have had to be purchased at current market prices, and transportation costs were paid in the ordinary way. This is 9s. 6d. more than the figure given by Sir Lowthian Bell in 1890 as the corresponding costs of West Coast Bessemer pig. Whether that region will again reach the level thus given for that year, or whether the present conditions of cost in the United States are likely to continue, are matters that are beyond my powers of forecast.

The Southern States.

Here again, for purposes of comparison, it is of advantage to take a survey over a number of years. Some ten years ago the cost of producing pig-iron in that region, as illustrated by the experience of the Thomas furnaces of the Pioneer Mining Company, which I had the opportunity of examining in 1901, was as under:—

	Cwt.		s. d.	s. d.
Iron Ore	50·42	at	4 3·12	10 8·87
Limestone	9·00	at	2 7·2	1 2·04
Coke	30·26	at	11 2·40	16 11·34
Labour				7 7·77
Management and fixed charges				0 3·89
Repairs and Stores				0 11·13
Total				37 9·04

During the next three years, costs were much lowered owing to the acute trade depression that had come upon the southern iron industry. In 1894 Mr. E. C. Pechin startled the iron-making world in the United States, and probably in Europe as well, by announcing that in Alabama pig was being produced at less than 6¼ dols. per ton. Itemised cost sheets were shown him, and he was permitted to use the figures. The following for one month, covering a production of 12,000 tons from two furnaces, was stated to fairly represent the work over a period :—

Cost per ton—Coke at Cost	2·313 dols.	
" " Ores "	2·147 "	
" " Limestone	0·164 "	
		4·624 dols.
Labour	0·795 "	
Incidentals	0·940 "	
		1·735 "
		6·359 "

The items making up incidentals were carefully noted—50 cents for renewal, and the balance covering oil, waste, taxes, insurance, office and general expenses. For many months all of these items, including labour, had not exceeded 2 dols. One reason for the low labour cost was stated to be that there was little double handling of stock.

In 1891 a comparison* was made of the cost of producing iron in four prominent districts of the United States, taking, in each, blast furnaces of nearly similar dimensions, well located, managed and

* Report of Committee to Marquette Board of Trade.

equipped. The relative cost of the different items showed that the expense for fuel per ton of pig-iron of similar character and grade made, was then lowest at Pittsburg and highest at Chicago, whereas the cost of ore per ton of pig was lowest at Alabama and highest at Pittsburg.

Labour, per ton of product, however, was reported highest in the Birmingham district, and was lowest in the Pittsburg and Chicago districts. The latter item was largely influenced by the relative quantities of raw materials handled, and the output of the furnaces. It is possible that at the present time the comparative items would hold nearly the same relations as in 1891.

In several of the leading districts of the United States, the general costs of producing pig-iron are much alike. In the neighbourhood of Pittsburg (Pa.), Wheeling (W. Virginia), Youngstown (O.), and Cleveland (O.) the cost of assembling the materials at works will differ very little over the whole, so that the chief items of difference will be the resources of individual firms in respect of raw materials, equipment, management, methods and men.

The situation in the southern States to-day is not likely to bear out the anticipations of those who predicted some years ago that Alabama and Tennessee could make pig-iron at 5½ dols. per ton. No doubt these districts are remarkably well placed for supplies of raw material, but they have to deal with materials that are not the most tractable, and require a good deal of humouring. The consumption of coke per ton of pig-iron is half as much again as in the Pittsburg district, and labour is not so easily handled. From several of the leading iron-masters in Birmingham (Ala.) I learned that the average cost of producing pig-iron to-day is about 8 dols. (33s. 4d.), although it was claimed that one, or perhaps two of the smaller firms, who are specially well placed, may produce it for a dollar less. I should add that the new administration of the Tennessee Company's works at Ensley have notified that they intend to aim at 6-dollar pig in their scheme of reorganisation.

General American and British Conditions.

One of the questions that were submitted to us by Mr. Schwab, in an interview that we had with him in New York, was this: "Assuming that British works were equipped with blast furnaces similar and equal to those owned by the Carnegie Company at its best works, and could, therefore, produce pig-iron as cheaply as the Carnegie furnaces are doing, what would be the cost of the materials at the furnaces, per ton of pig-iron?"

This question opens up the whole range of problems that are related to the ultimate cost of pig-iron production. These include the cost of the ore at the mines, the costs of transport by land and sea, dock and harbour dues, conditions of handling materials, and cognate matters. The difference of having furnaces that produce on a large scale against furnaces that produce on a relatively small scale is also material.

To begin with, the cost of the sea transport of our imported ores is twice to three times that of the cost of conveying Lake Superior ores

from the mining regions to Lake Erie ports, although the distance is not greatly different. The distance between Bilbao and British ports is not more than 800 miles, and that distance has to be covered by a great deal of the ore sent from Lake Superior. But the Lake Superior freight within the last few years has not exceeded 50 to 60 cents (2s. to 2s. 5d.) for the whole distance, whereas the average rate of freight from Bilbao to British ports is not less than 5s. per ton. We have here a difference in the water freight alone of 3s. to 4s. per ton of pig-iron, assuming two tons of Spanish ore and 1½ tons of Lake Superior ore to be used. Of course, the Lake Superior ore has usually to break bulk twice, and has to perform a railway journey varying from 150 to 250 miles, taking both ends into account, whereas the Spanish ore for British consumption has usually a railway journey of only a few miles at each end, and in some cases—as in that of Bolckow, Vaughan & Company's wharf, on the Tees—is delivered by ship at the works.

In the conditions of the transport of fuel there is not usually such a difference against the British situation, so far as the cost of assembling of materials is concerned. Most of the furnaces in and near to Pittsburg are within 60 miles of coke supplies, and some of them are much nearer; thus they are able to cover at a freight rate of 50 to 75 cents, which compares with a freight rate of 2s. to 3s. for the transport of coke from South Durham to Cleveland. In the case of the Chicago plants the coke has to be taken over much greater distances at a freight rate of 2 to 3 dols. per ton, which compares with the situation of West Cumberland and North-West Lancashire, where the coke freight is between 6s. 6d. and 8s. per ton, and with the similar rates paid by such districts as those of Northamptonshire and Lincolnshire.

There are not many cases in the United States where the ironmaster can avoid payment of a more or less considerable coal and coke freight charge—in other words, where he has the control of his own fuel transport. Some of the southern furnaces are in this happy position. At Birmingham, Alabama, I saw coal mines and coke ovens within half a mile of the blast furnaces of the Tennessee Coal, Iron and Railroad Company, and there are similar cases in other parts of the southern and eastern States. Speaking generally, however, probably three-fourths of all the iron works of the United States have to look to the public railway companies for the transport of their fuel supplies, and have only a limited control over their charges. In Great Britain there are, perhaps, a larger number of plants that are carried on like the Consett and Bestwood Works in England, Dowlais and Ebbw Vale in Wales, and several others in Scotland, in the immediate neighbourhood of their fuel supplies. The British geographical conditions are probably more favourable than the American, apart from the incidence of railway charges, speaking generally ; but, of course, in both countries there are notable exceptions to this and to every other general rule.

Nor can we find anything in the price records of the American markets to cause serious alarm. One of the staple and standard products of the American iron trade is No. 1 foundry pig, of which the lowest price in any one year—that of the year 1898—was 48s. 7d. at Philadelphia. At least 10s. per ton additional would be required to land this iron on British soil, making the price 59s. 7d. But Scotch

foundry iron has been sold in large quantities at 40s. per ton, and that price can possibly be maintained with profit, under normal conditions, over a protracted period.

Much might be said of the conditions, apart from cheap materials, that enable American blast furnace owners to produce cheaper pig. Professor Howe has declared that the American system of large outputs " lowers the charges for installation, interest, taxes and insurance," while he denies that it " causes excessive wear and tear, or lessens the life's work of the machinery and plant." Great output, he points out, is due rather to shortened intervals of disuse than to rapid motion. The same writer has suggested that rapid working permits a lower average degree of intelligence, and thus a lower average price of a day's labour—a fact which he seeks to support by quoting the case of an American Bessemer plant, where 52·8 per cent. of the workmen were wholly unskilled, whereas in a Continental similar establishment he found that only 13 per cent. of the whole could be classed as labourers. On this interesting economic study I cannot stay to dwell, but I may remark in passing that Mr. Andrew Carnegie some years ago declared that at Homestead, which has a high reputation for quick working, the average wage paid to all workmen, as I have elsewhere indicated, was much above the ordinary labourer's range.

Economy of Producing Steel between 1890 and 1899.

Although the conditions and costs of producing pig-iron are the controlling factors of supremacy in the iron industry, yet there is much to be said as to the conditions under which steel is produced, a fact which is accentuated by the remarkable progress achieved by one or two of the leading steel-producing firms in the States, and more especially by the success of the steel-making concerns that do not attempt to either sell or export pig-iron.

The records of the United States Census Office show that the average capital outlay per ton of steel produced was, in Pennsylvania, 36·4 dols. in 1880, and 34·9 dols. in 1890; that the average cost of materials per ton of finished product was 37 dols. and 26 dols.; that the average output per employé was 37 tons and 60 tons; and that the average wages paid per ton of product was 12·1 dols. and 9·4 dols.

From these facts it is clear that the steel industry had made considerable advances in the ten years ending with 1890. It is, however, mainly since that year that the steel manufacture has made its greatest strides in every direction, and it is wholly since that date that costs have been so far reduced as to enable the United States to compete with Great Britain and Germany in the leading markets of the world.

My friend, Mr. C. Kirchhoff, in his admirable presidential address to the American Institute of Mining Engineers in February, 1899, gave some valuable information as to the wonderful decrease that had taken place since the year 1890 in producing steel. He showed that practically the cost of producing Bessemer steel ingots had diminished

by about one-half between 1887 and 1898. The items for each of these years are appended, the figures for 1898 being stated as percentages of a unit of 100 based on the cost in 1891 :—

	1891. Single turn.	1898. Double turn.
Pig-iron (less credit for cinder, etc.) ...	63·54	41·54
Scrap (excluding that produced)	11·96	6·28
Spiegel...	12·19	7·89
Limestone	·24	·20
Fuel	1·59	1·60
Steam	·31	·38
General supplies, taxes, etc	3·04	1·81
Moulds	1·50	·45
Labour	5·63	4·24
Total cost per ton	100·00	64·39

As regards the costs of steel billets at the present time and in the near future, it is impossible to fix a figure that can be adopted as a standard. The lowest approximation I have hitherto met with was given some two or three years ago by the *Iron Age*, when prices generally were much lower and the general range of wages was under those now and since prevailing. It is, however, just such periods that are mainly of interest to the British iron trade, when competition becomes a serious matter. In that estimate it was assumed that the cost of Bessemer pig was 10 dols. per ton, and that the items of conversion into billets totalled 4 dols. 75 cents, of which the principal items were :—

	Dols.
15 per cent. for waste in conversion...	1·50
Labour of all kinds	1·10
Ferro-manganese	·40
Coal and coke	·60
Repairs, etc.	·35
Limestone, moulds, supplies, etc.	·80

Here we have a total estimated cost of 61s. 5d. per ton of billets. At the present time the selling price of billets is about 120s. per ton, and the cost of production given is considerably less.

A leading authority, speaking of March of last year, thus summed up the question of steel costs at that time :—"Supposing molten metal costs 13·50 dols., 2 dols. per ton additional will make the ingot cost 15·50 dols., and 1 dol. additional will put the ingot into billets at a cost of 16·50 dols. per ton. The present price of [illegible] billets at Pittsburg is about 20·50 dols., a difference of 4 dols. per ton. A modern merchant mill will convert these into merchant bars for an additional cost of 3·50 dols., which makes the cost of the bars 20 dols. The present price of merchant bars at Pittsburg is 30 dols. per ton, making a difference of 10 dols. Or, if rolled into rods in a modern mill, 3·50 dols. additional will convert the [illegible] billets into rods, making the cost of these 20 dols. The present price of rods at Pittsburg is 35 dols., making a difference [illegible] dols. per ton."

Some months ago, Mr. Joseph Lawrence, M.P., informed a British audience* that he had been informed by Mr. C. M. Schwab that the Steel Corporation could deliver steel billets in England at 16·50 dols. (68/9), against £3 19s. 2d., which was stated to be the lowest price at which they could be produced at British works. This statement was startling enough, but its value was seriously prejudiced by two important omissions—first, that of how far the American price carried a profit, if any; and the second, the locality in which, and the conditions under which, British works were assumed to compete.

Taking it that the cost of producing American pig-iron has of late materially increased in the main, the average manufacturer is not likely to be able to produce steel billets at 68s. 9d. per ton, the price named by Mr. Schwab. But, even so, the British rail manufacturers in bygone years have produced and sold hundreds of thousands of tons of rails for less than that figure. I may add that within the last few months an important proposal has been brought under my notice, looking to the establishment of large iron and steel works in the Midlands on modern lines, where it appears to be probable that basic pig-iron can be produced for about 30s. per ton, and steel billets for about 67s. per ton, which, if realised, would, of course, entirely upset the idea of a British minimum billet cost of £3 19s. 2d. per ton. In the North of England, I have reason to believe that an equally low cost may be reached under the new conditions estimated to result from the Americanisation of some of the leading plants.

* Address to the Newport Chamber of Commerce, 1901.

SECTION VII.

CHAPTER X.

The Manufacture and Treatment of Finished Steel Products.

A.—STEEL RAILS.

FOR a number of years the production of steel rails was one of the principal, as it was also one of the earliest branches of that industry. Practically, this industry was begun in the United States in 1867, when the total output was 2,277 tons, and the average price in currency was 166 dols., or £34 7s. 10d., the duty on imported rails at the same time having been 45 per cent. *ad val.* Ten years later, the output had risen to 385,865 tons for the twelve months, and the average annual price was 45·50 dols. (£9 19s. 6d.) per ton, the duty on imports being then 28 dols. per ton. Ten years later still, in 1887, the output of rails for the first time exceeded two million tons a year (exactly 2,101,904 tons) the average price for the twelve months having been 37·08 dols. (£7 14s. 6d.) per ton, while the duty on imports was 17 dols.

In the following thirteen years, the course of the American rail industry had been marked by great fluctuations, the output having been as high as 2,361,921 tons (in 1900) and as low as 1,016,013 tons (in 1894), while the maximum annual price was 32·29 dols. (in 1900), and the minimum (not annual) was 17·62 dols. (in 1898). In the meantime, the rate of import duty had fallen in August, 1894, to 7·84 dols. per ton, at which figure it still remains.

It will be noted from these records of output and price—all given on the authority of the reports of the American Iron and Steel Association—that the rail trade of the United States is characterised by conditions of "unstable equilibrium," and that even in the period 1898-1900 there was a difference of nearly 100 per cent. in price, and in the period 1894-1900 a difference of more than 130 per cent. in output.

Increased Outputs of Steel Rail Plants.

About 1880, the rapid growth of the American rail trade, and the large outputs got from American works, began to attract attention in this country. I therefore suggested to the Council of the Iron and Steel Institute—of which I was at the time the secretary—that I should ask my old friend, the late Captain W. R. Jones, at that time general superintendent of the Edgar-Thomson Steel Works, to prepare a paper for the Institute on the conditions of the American rail industry. Captain Jones readily responded to the request for such a paper.* He

* "On the Manufacture of Bessemer Steel and Steel Rails in the United States." *Journal*, No. 1, 1881, p. 129.

showed in this paper that in the year 1880, a pair of 7-ton vessels had produced 123,676 tons of ingots, and 100,094 tons of rails. This was at the time regarded as phenomenal, and almost, indeed, as incredible. Captain Jones did not live to see the same works, with a three-vessel plant, produce, as they did a few months ago, 3,391 tons of ingots in twenty-four hours, or, assuming only 300 working days, at the rate of over a million tons of ingots per annum, while on the same day No. 1 rail mill produced 2,181 tons of finished rails, being at the rate of 655,500 tons in 300 working days. Captain Jones was proud of his record of 123,676 tons of ingots bloomed in a year, but the corresponding output from one blooming mill has recently been as much as 2,980 tons in twenty-four hours, or at the rate of 894,000 tons in 300 working days. Mr. E. Windsor Richards, in the course of the discussion on Captain Jones's paper, spoke of an output of 125,000 tons as so enormous that he saw little probability of attaining it in England, and yet the rate of output had advanced to six times that of the earlier period within twenty years.

When I visited the Edgar-Thomson Steel Works in 1890, the best rail-making record attained up to that time, and one of which Mr. C. M. Schwab, the then superintendent, was very proud, was 1,417 tons of rails per day, and 7,222 tons per week. When I paid my second visit to the same works in October of 1901, the best records had been 3,495 tons of ingots from four 15-ton converters, and 2,914 tons of finished rails, in the twenty-four hours. The latter output was got from two rail mills—one used for heavy, and the other for light sections.

This improved output is largely a function of accelerated methods of handling materials, whereby in the converting department they are often able to get 120 to 125 blows in the twelve hours from three converters, 121 blows having been the record for the night previous to my visit.

In the interval much has been done to economise the methods of production, although in 1890 the system generally adopted at these works was regarded as the best then known. All the plant used for the strippers, soaking pits, etc., is electric, except the tongs used to lift the ingots, and these are worked by compressed air. The ingots are cast on cars, there being two moulds to each car, and 30 to 50 moulds in a train. In handling the ladles, the cranes are designed to handle two at a time. An ingot is bloomed in 30 to 40 seconds, in seven passes. In another mill—a three-high blooming—nine passes are usual. Rails are rolled in lengths of 90 ft. An electric trolley, running at a high speed, carries the rails from the one mill to the other. The whole mechanism, as far as possible, is automatic, including a very ingenious system of transfer from one set of rolls to the other, devised by the chief draughtsman, Mr. E. Slick.

Cost of Rail Production.

Mr. J. Schoenhof ascertained that the labour cost of producing steel rails in Great Britain, in 1888, was 3s. 6d. for conversion ; 8s. in making rails from the ingots, and 1s. for additional labour. At that time, the cost of producing Bessemer pig was computed at 17·77 dols.

in Eastern Pennsylvania, and 10·83 dols. in Middlesbrough (England). The details, as given in an American Consular Report, were :—

	Eastern Pennsylvania.	Middlesbrough.
Ore	11·00 dols.	6·56 dols.
Limestone	·40 „	·33 „
Fuel	4·50 „	2·55 „
Labour	1·25 „	·79 „
General expenses	·12 „	·12 „
Sundries...	·50 „	·48 „
Total	17·77 dols.	10·83 dols.

The same careful and competent economic writer made an investigation into the cost of manufacturing steel rails in Pennsylvania, and found that it was composed of the following factors, as given from the mill account :—

COST OF MANUFACTURING A TON OF STEEL RAILS IN EASTERN PENNSYLVANIA.

One ton of pig-iron	18·00 dols.
Three hundred-weight spiegeleisen	4·00 „
Fuel	2·00 „
Labour	3·04 „
Sundries	·50 „
Additional labour (unexplained)	·84 „
Total	28·38 dols.

In analysing the figures placed at his disposal, Mr. Schoenhof showed that the output of Bessemer steel rails per week in this rail mill was 4,500 tons; the total number of men employed, 1,048; the output of tons per man employed, 4·3; the average wages paid per day, 2·17½ dols.; the labour cost per ton of all employed in the steel mill, 3·04 dols.; while the tons of Bessemer steel rails turned out per week in a rail mill in England were 1,500; the total number of men employed, 600; the output of tons per man employed, 2·5; the average wages per day 5s. 6d. = 1·33 dols.; the labour cost per ton of all employed in rail mill was 11s. 6d. to 12s. 8d. = 2·80 dols. to 3·08 dols.

The same writer published the following particulars of rail-making costs in the United States by the basic and acid processes of Bessemer steel manufacture :—

Basic Steel.	s.	d.	Acid Steel.	s.	d.
1·311 tons of pig	43	8¼	1$\frac{1}{10}$ ton hematite	49	6
0·141 tons of ferro... ...	9	10¼	1½ cwt. ferro...	6	0
Fuel...	5	4	14 cwt. coal	5	3
Labour	10	3	Labour	12	8
Other charges	8	10½			
Total	78	0	Total	73	5

In the case of basic rails other charges include lime, limestone, tar, refractories, castings, stones, and maintenance. These are higher in basic than in acid rails, but in both cases the greater part of such

charges is off-set by the credit deduction for value of ends and defectives.

The total cost of all labour in producing a ton of steel rails, including that on raw materials, in 1890, was given by Colonel Wright for a number of works, of which he had obtained particulars, at the following figures :—

	Labour.		Transport of Mineral.		Stores and Standing Charges.		Total.	
	s.	d.	s.	d.	s.	d.	s.	d.
United States	48	0	24	6	18	0	90	6
Great Britain	32	5	17	5	18	4	68	2
Continent of Europe ...	31	6	14	10	15	4	61	8

The labour cost of producing the finished rail from the stage of pig-iron is thus compared by the same authority :—

	On Ingots.		On Blooms.		On Rails.		Total.	
	s.	d.	s.	d.	s.	d.	s.	d.
United States	10	10½	not bloomed		10	3	21	1½
Great Britain	4	1	3	6	6	10	14	5
Continent of Europe ...	4	0	1	7	5	0	10	7

Hence it appears that at this time, according to the examples given, the cost of labour in the steel rail manufacture was about 50 per cent. greater in the United States than in Great Britain.

Hands Employed in American Rail Mills.

When the earlier records of converted blooming mills and rail mills were brought under notice, there was a general impression on the part of the British rail manufacturers that they could only be accomplished by overloading the works with labour.* One of the speakers, in the discussion already named, expressed the opinion that "there must be a very large number of men about the pit."† The president of the Institute, in closing the discussion, expressed the view that "a greatly increased expenditure for labour and wear and tear might not be compensated by increased production."†

I am not able to give the numbers of men employed at the Edgar-Thomson Works in 1880, but on the occasion of my recent visit there, I obtained the following list of hands employed in the converting department and at the No. 1 rail mill.

In Converting Department—

60 tonnage men.
90 men as fixed labour.
75 men as general labour.
60 turn men.
10 scrap-men, brakemen, etc.

———

295 men in all, which is increased to 310 by other additions.

* *Journal of the Iron and Steel Institute*, No. 1, 1881, p. 143.
† *Ibid.*, p. 145.

At No. 1 *Rail Mill*—

22 rollmen.
12 engineers, etc.
12 men working round furnaces.
10 turn men, working levers, etc.
12 clerks and recorders.
7 foremen, etc.
—
75 in all.

The No. 2 rail mill employs a total of 30 men.

By dividing the product obtained on the recent occasion already referred to, it will be found that the output per man employed was 11 tons in the converting department, and 29 tons at the rail mill per 24 hours.

The Morrison-Kennedy System of Treating Rails.

One of the latest and most interesting improvements adopted at the Edgar-Thomson Works is known as the Morrison-Kennedy system of rail treatment, under which the rail, on the way to the finishing rolls, is arrested for a minute to a minute and a half, and is placed on a cooling table, the effect of which is to cause a notable change in its granular structure and physical qualities. Ordinarily, in a rail rolled at a high temperature, the granular structure is large, but after being detained on a cooling table, as described, the grains become much more minute, with better results under tensile and drop tests. This new system of treatment is now adopted at the Edgar-Thomson Mill in all heavy rail contracts, although I was informed that the company make no extra charge for the increased cost involved. Four sets of rolls are used, against only one set under the ordinary system. The new system is not applied to light rails. In regard to labour, one man more is required on each turn.

The rail mill at the Edgar-Thomson Works, as now equipped, consists of three trains of rolls. In the roughing train, the bloom is passed forward and backward through five passes; it is then run to the intermediate or "short" rolls, where it is given five passes in the same manner. The partially rolled rail, which has been elongated until it is now about 90 ft. in length, is then run to the special cooling table, which is but a few feet to the right of the main run, on which the rails are passed, and which affords an interval for the passage from the intermediate to the finishing rolls, during which time every individual rail can be brought to the same temperature, this temperature being that which has been found to produce the best results.

The rail is carried by the intermediate rolls and delivered to a special cooling table by means of six "dogs" or "latches" attached to ropes connected with drums on a common shaft, operated by means of a hydraulic cylinder and rack. Each of these ropes carries a second dog, the first set of dogs being adapted to draw the rails on to the cooling table and to push over all the rails then on the table, which may amount to six or more, while the second set

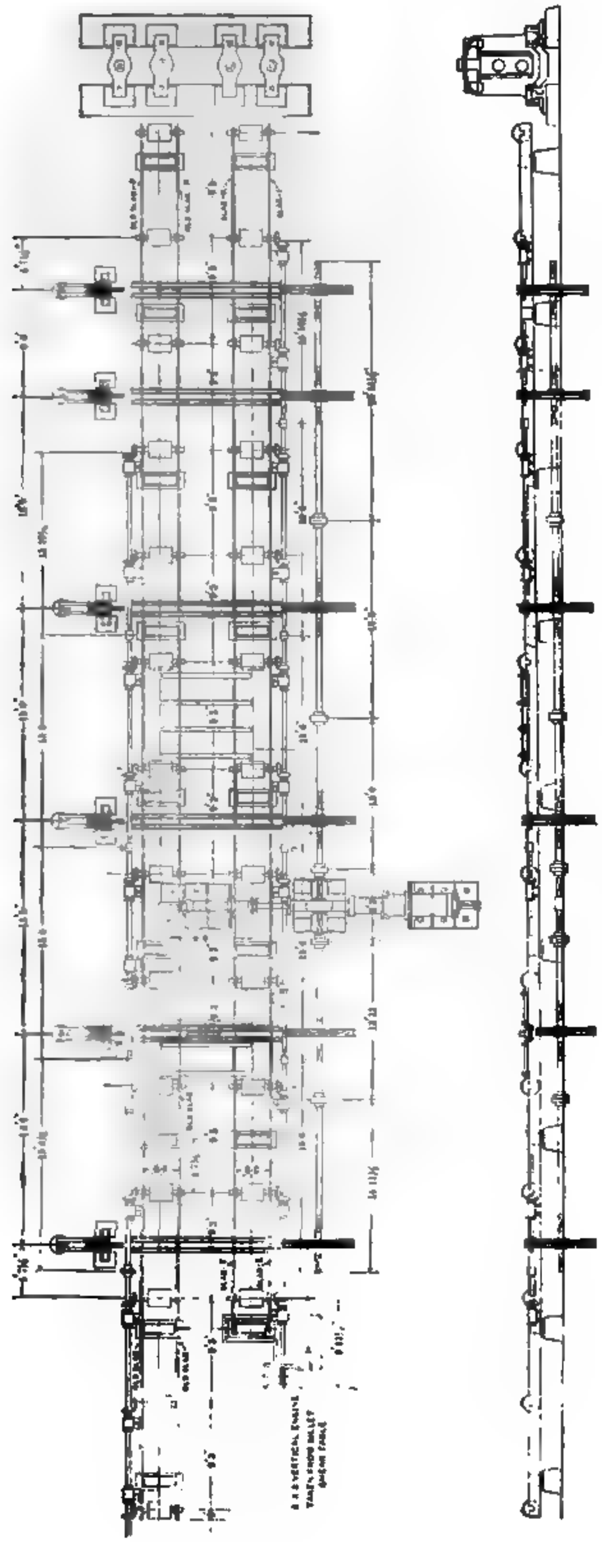


Fig. 26.—Plan and Side Elevation of Cooling Table.—The Kennedy-Morrison Rail Finishing Process.

of dogs is arranged to draw one piece at a time on to the feed table of the finishing rolls, thus avoiding any danger of two pieces at a time being carried forward to the rolls. After leaving the finishing rolls the usual processes are carried through, except that the rails do not need quite so much curving in the cambering rolls, on account of having less difference of temperature between head and flange than would be the case in the ordinary method of rolling.

The steel rolled at the lower temperature is found to be finer in structure, and to give a tougher and better wearing quality. The tensile, drop, and other tests also show better results than in the same section of rails rolled in the regular way.

The type of three-high blooming mill which is illustrated in Fig. 27 is to be met with in many leading American steel works, including Edgar-Thomson, Joliet, Lackawanna, Union (Chicago), Pueblo (Colorado Fuel and Iron Co.), and the works of the Jefferson and Roane Iron Companies.

Rail Testing and Inspection.

The testing and inspection of the rails produced at the Edgar-Thomson Works are simplicity itself. The test for heavy rails is a drop test of 2,000 lbs., falling 18 to 20 ft., depending on the size of the rail to be tested. The rails are inspected as they come from the mill. The main thing is to get them rapidly out of the way. When the rails have been straightened, after coming from the finishing mill, they are examined by the inspectors, and defectives are thrown out. Outside the mills the rails are again gone over by the company's own inspector; and they are finally inspected on the rail bank by the buyer's inspector. Two outside inspectors are generally on the works. The rule in the United States is to require less rigid tests than in England, the drop test being usually deemed sufficient, whereas drop, tensile, and dead load tests are all required in British practice.

The function of the American rail inspector, as set forth in the hand-book issued by the Pittsburg Testing Laboratory, a copy of which was handed to me by Mr. George H. Clapp, who is chairman of this important organisation, is as under:—

"To inspect the surface of every rail, seeing that the section is in accordance with templates; that the weights and lengths are correct; that the rails are straight; verifying the distance and spacing of the drilling machines, and seeing that the shipping directions are properly carried out. This, in addition to making regular tests of the quality of the steel being used, and noting that the analyses of the steel made at the mill laboratory are in accordance with the specifications; seeing that all irregular steel or that which is brittle, hard, or too soft, is rejected. They check all weights and verify the numbers and weights of all invoices, and send through our central office duplicate copies of all invoices and lists of shipments, together with the inspector's certificate."

The Rail "Record" System.

It must not too hastily be assumed that in the United States the conditions of working generally stand at the same high level as that recorded for individual examples. Even authorities differ as to the

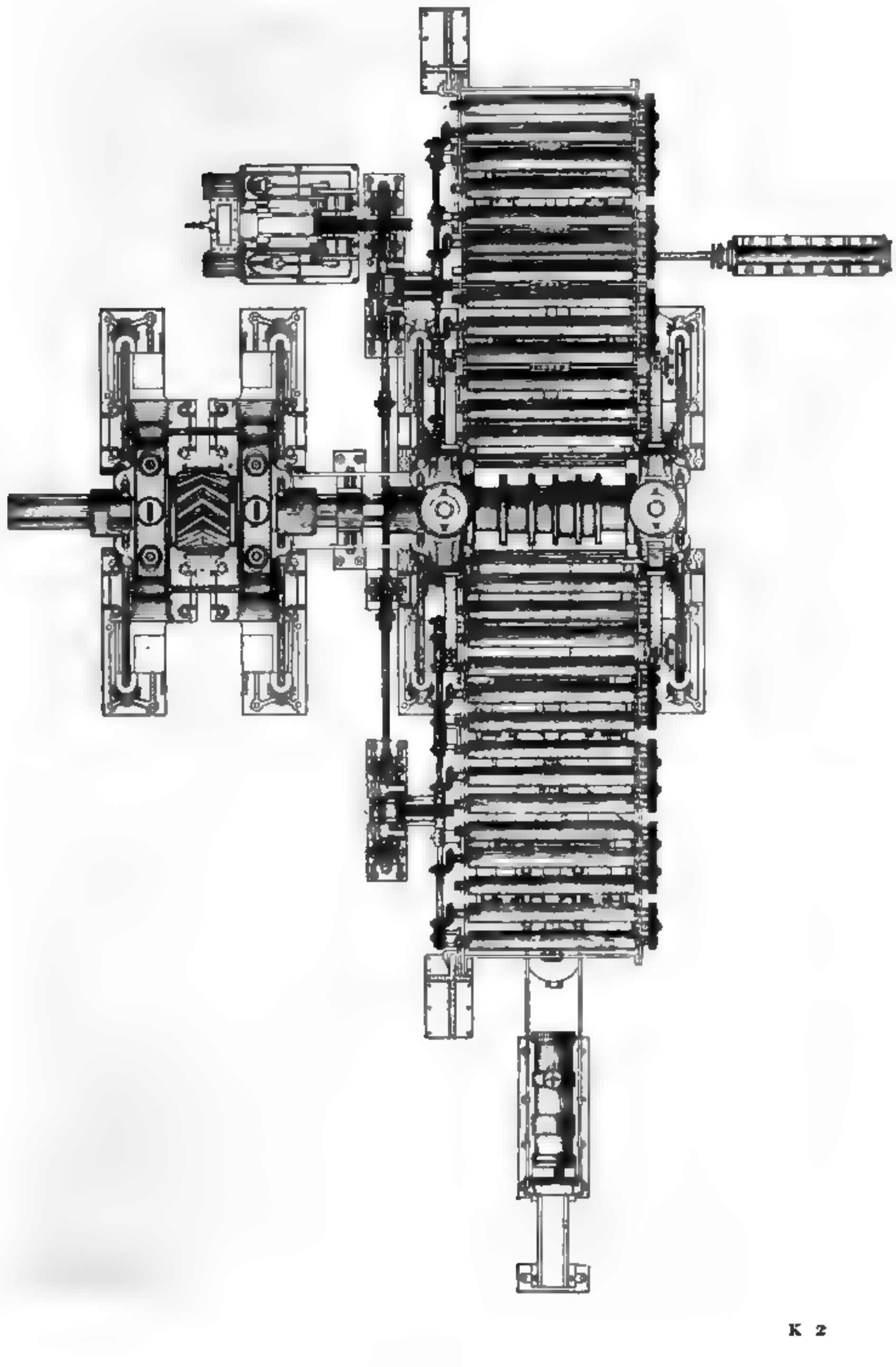


FIG. 27.—THREE-HIGH BLOOMING MILL—PLAN.

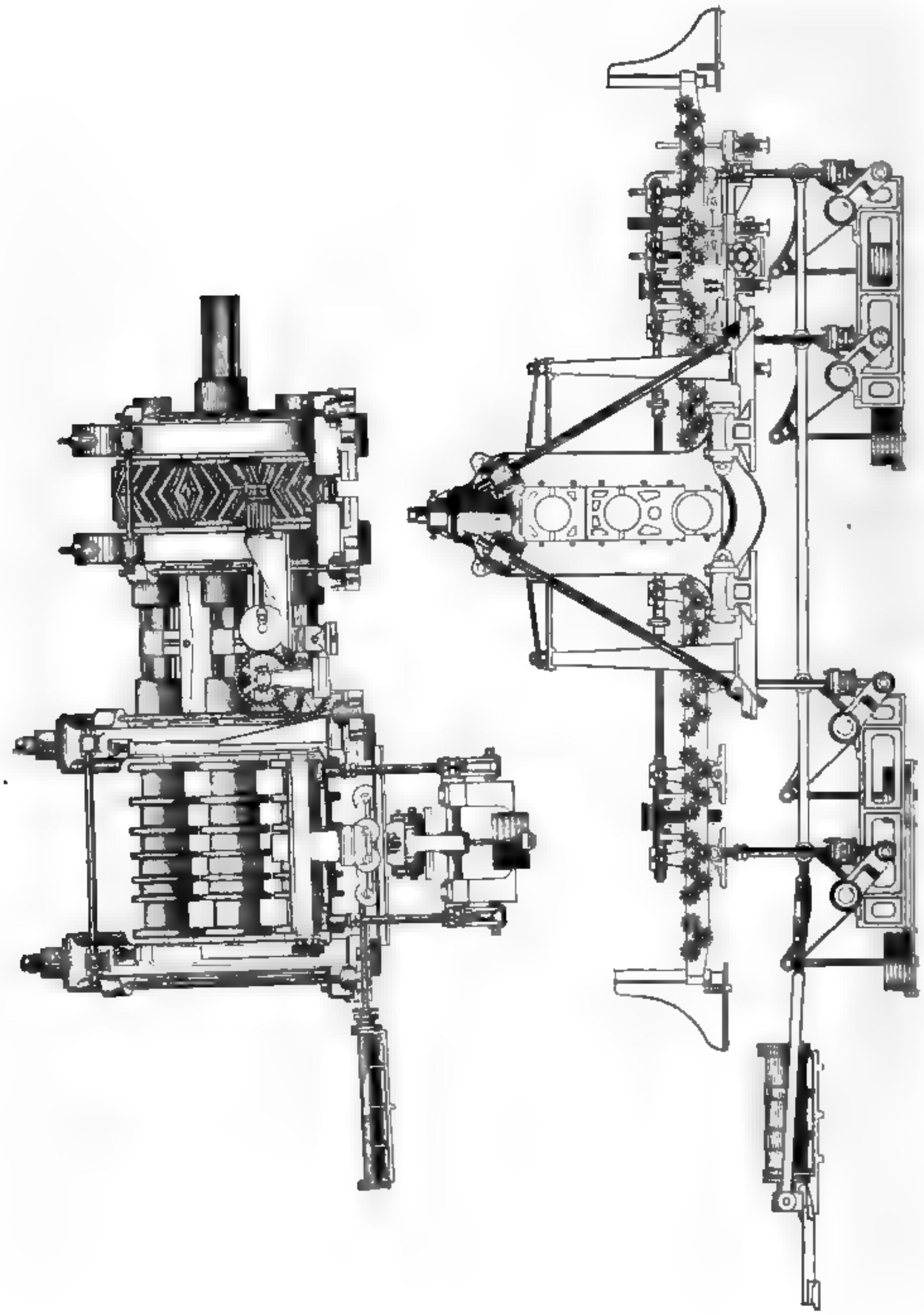


Fig. 28.—Three-High Blooming Mill—End and Side Elevations.

effect of the system of records now so characteristic of the American steel works. At the same meeting a few years ago, two well-known American experts—Mr. E. C. Potter and Prof. Howe—expressed views that were not easily reconciled on this very point. Mr. Potter declared that the desire for large tonnage led to "slovenly, careless work"; and he adds: "In the mad struggle for supremacy everything goes with a rush; scrapping carelessly done, blowing more or less inaccurate, heats poured hurriedly and in a slovenly manner, nozzles in ladles badly set, and imperfect streams resulting, moulds carelessly and irregularly set in their stools, causing large fins on the bottoms of ingots, moulds insufficiently cooled, and ingots stripped too soon," and much more to the same effect; "any or all of which," Mr. Potter added, "would seriously impair the quality of the product."

As an exponent of the other side of the question, Mr. Howe has stated that "the cracks and blow-holes to which careless teeming should lead, would in turn lead to physical defects in the rails, due to cracks; hence should result a large proportion of second quality rails, of cobbles, of rolling-mill scrap," whereas the proportion of second quality rails is stated to be not more than 3 per cent. in mills using direct metal. "We do not," adds the same writer with some *naïveté*, "humour peculiarities; we prevent them."* But there is hardly likely to be any specific at the command of the American mill-manager which will exempt him from the usual consequences of careless work—if the work is careless, or from the penalties attendant on hurry—if the work is done too hurriedly to be done well.

Steel Rail Composition and Sections.

In respect of both composition and sections, American steel rai practice differs materially from that of Great Britain, but I need not discuss either at any length, nor, indeed, would it be necessary to refer to them at all, but for the fact that both have been simplified as much as seems possible in the interest of manufacturers. Low phosphorus rails—about 0·06—are in special demand, and for some years the Bethlehem and one or two other companies obtained a bonus of two dollars per ton on steel rails, and conformed to what is known as the Dudley specification, although a number of companies now produce rails of this description without any addition to the regular price. Basic steel is not as yet used to any extent for rail manufacture, but the Tennessee Company are now about to use it on a considerable scale at their new rail mill in Alabama.

In 1900, it was estimated that about 70 per cent. of all the rails rolled in the United States were manufactured to the section prescribed by the American Society of Civil Engineers, who, as stated in a recent report, have "simplified and standardised practice, to the advantage of railroads and rolling mills, and to the comfort and relief of railroad engineers." The system of cooler rolling of the rails has, however, shown that this section is relatively too thin for the best results, and hence a committee has lately been appointed to consider suggested

* "Proceedings of the American Institute of Mining Engineers," 1890.

modifications of the section in question. In Europe, the weights on the locomotive driving wheels are limited generally to about 14 tons, but in the United States no such limit is imposed upon either drivers or car wheels, although recently there has been a demand for rails of higher physical properties to cope with the heavier loads now common.

Resources of Steel Rail Production.

At the end of 1901, there were in the United States 45 completed rail mills, and three new mills were in course of construction. These figures compare with 51 rolling mills which were prepared to make standard girder, light T and other iron and steel rails, in 1898. The works belonging to the Steel Corporation at the end of 1901, which were engaged in the manufacture of steel rails, and their capacity, were as under:—

Works.	Total Tons.
Edgar-Thomson, Pittsburg	650,000
South Works, South Chicago	650,000
Joliet Works, Joliet	540,000
Milwaukee Works, Milwaukee	150,000
Union Works, Chicago	270,000
Lorain Works, Lorain, Ohio	500,000
Total	2,760,000

This product includes a certain proportion of billets, and also light rails to a material extent, but probably the rail capacity ordinarily available will not be less than 2¼ million tons.

The works that are, or were, independent—for changes take place rapidly in the United States, and other consolidations were then being, and have since been, a good deal talked about—included eleven rail mills in Pennsylvania, three in Alabama, three in Maryland, six in Ohio, four in Indiana, two in Illinois, one in Missouri, one in Kansas, and one in Wyoming. The aggregate capacity of these works is not ascertainable. A number of them are specially designed for light rails. Others have been built to re-roll steel rails by the McKenna process. Others, again, are employed exclusively on mine rails. But it is clear that the independent plants—in which I include those of the Republic Iron and Steel Company, as being distinct from the Steel Corporation—are in a large majority, and are not, for that reason, likely to be swamped by any consolidation hitherto established. Nevertheless, the total rail-making resources of the United States are colossal, and they are likely to be very considerably augmented when the new rail mills now being built by the Lackawanna Iron and Steel Company at Buffalo, the Tennessee Company at Ensley, and the American McKenna Process Company at New Jersey, are completed.

B.—THE MANUFACTURE OF PLATES.

The manufacture of ship plates having been for a number of years past the largest individual branch of the steel industry of Great Britain, I made it my business to visit several of the works engaged in

producing steel plates in the United States, including those of Lukens and Worth Brothers, at Coatesville, and the works of the Carnegie Company. The principal makers of ship and boiler plates in the United States, besides those enumerated, are Messrs. Park Brothers, the Carbon Steel Company (Pittsburg), the Otis Steel Company (Cleveland), the Pottstown Iron Company (Pottstown), and the Glasgow Iron Company. The total output of plates at these different works must considerably exceed half a million tons a year. Confident in the future of their shipbuilding industry, some of the American ship plate makers are looking forward to an extension of their plants in the near future.

There is no separate record of the number nor of the capacity of the steel plate mills in the United States, as distinct from the record of plants engaged in making sheets. In his *Directory*, published early in 1902, Mr. J. M. Swank gives the total number of plate, sheet, and skelp mills collectively at 223, with 13 building and two projected. In 1898, however, the ascertained number of *completed* mills in this category was seven more than that recorded in 1901. Most of the mills in course of erection at the present time are designed to manufacture sheets. Nor is any distinction made between one description and another of plates. Boiler, ship, bridge, tank, and universal plates are not infrequently produced by the same plant. Some of the plants have vast capacities. The Homestead Works, for example, have four plate-mills—one 119-in. and one 128-in. three-high sheared plate mills, and one 48-in. and one 42-in. universal plate mills, so that plates must form a large part of their output of rolled products, for which their capacity is 1,300,000 tons a year.

The Lukens Steel Works.

At these well-known works, situated about 40 miles from Philadelphia, the manufacture of boiler plates is stated to have been initiated in the United States. The best known name connected with this pioneer work is that of Dr. Huston, father of the present proprietors, who started the plate industry by using single charcoal blooms, made in the old-fashioned forge fire, then reheated over an ordinary grate fire, and finally rolled out to the required dimensions. The plate rolls were then 16 to 18 inches diameter, and 3 to 4 feet in length between the housings, the motive power being an overshot water wheel.

To-day the works are in all respects up to date. They have 12 stationary open-hearth furnaces, six of them 50 tons and six others of 40 tons capacity, although nominally less. Six of the furnaces produce acid, and six of them basic steel. Basic steel, Mr. Huston told me, is preferred by the firm's customers, and it is more convenient to manufacture, as the analysis is quite as good, and the chemical requirements are more easily met. At Lukens they use the acid steel for a lower class product, finding it more subject to surface defects, pitting, etc. The general specification for basic steel plates is ·15 to ·20 C, ·02 P, ·03 S, and Mn ·40. The pig used has from 1·0 to ·5 per cent. P, 1·0 P, and low sulphur. Of limestone and burnt lime the quantity used as additions is about 200 lbs. per gross ton of ingots, while 12½ lbs. of dolomite and 32 lbs. of magnesite are used for the bottoms. Fluoride

of calcium is used as a flux to the extent of about 12 lbs. per ton of ingots.

The ingots are bottom-poured for direct rolling. The weekly output from midnight on Sunday to 6 p.m. on Saturday is about 600

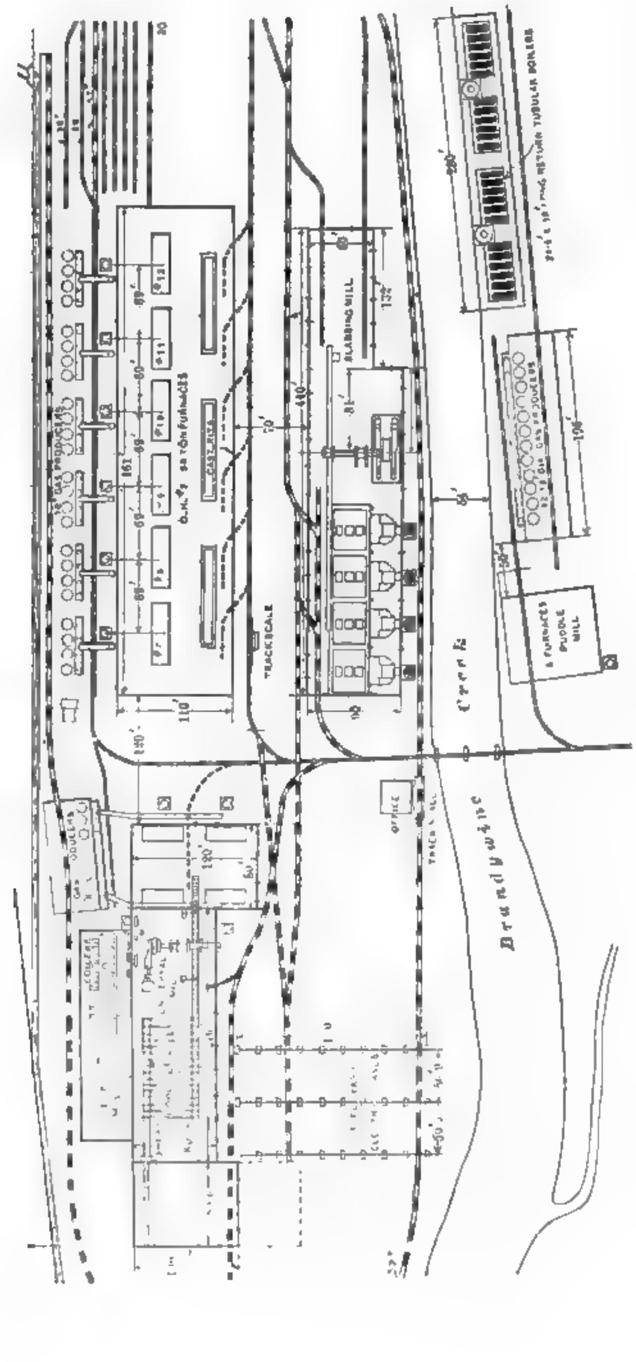


FIG. 29.—GROUND PLAN OF THE LUKENS IRON AND STEEL COMPANY'S PLANT.

tons for each 50-ton furnace. A larger output is got for slabbing. The basic loss is fully 4 per cent. There is no ore used to speak of that would flux out the lining.

Three mills are employed at Lukens—two of them sheared and one universal. The output averages about 9,000 tons per month (2,000 lbs.), made up of ⅗ths universal and the remainder sheared plates. Up to 10,000 lbs. finished weight is sometimes rolled, and up to 18,000 lbs. in the rough, the plates in this case being rolled direct from ingots, so that a large percentage has to be cut off to provide for segregation, etc. The middle rolls of the universal mill, which is three-high, are 28 and 20 in. respectively, and it can roll from 48 in. in width down to 9 in. One of the mills is of small size, and is worked by hand methods. The mills have produced 505 tons (2,000 lbs.) of finished plates, sheared and universal, in the 24 hours, of which 250 tons were produced by the universal mill. The mills are all continuous and not reversing. The Messrs. Huston believe that there is great economy of steam in continuous running, besides the saving of back-lash which occurs in the reversing.

The largest of the plate trains at the Lukens Works was installed in 1896, with rolls 120 in. long, and is of the three-high type, fitted with automatic tilting tables, and served by an hydraulic crane, enabling one man to draw ingots from any one of a number of heating furnaces and deliver them on the roll feeding tables. This mill was enlarged in 1900 with rolls 134 in. long and 36 in. in diameter, enabling the company to roll plates up to 132 in. in width. The plates are machine straightened while hot.

In 1899 a large plant composed of a 48-in. universal mill with a new open-hearth furnace plant, and in 1900 a slabbing mill, said to be more massive than any at present in operation in the United States, were added, making the new plant, which is set forth in the accompanying ground plan illustration (Fig. 29), one of the finest in the country.

The new universal mill building is of 400 ft. total length, the centre part being 130 ft. wide, while the end spans are transverse to the main span of the centre building. This centre span contains roll trains, engines, mill roller tables, run out tables, cooling bed, shear tables and shears, the latter being at the end furthest from the furnaces. The ingot is delivered by the roller tables to the mill, where it is handled entirely by power devices back and forth through the successive passes in the mill, and the finished plate is delivered hot to the run out tables and cooling bed. The plate is gradually moved sidewise, when cold, to the roller table feeding the shears, where it is cut to the proper length, passing through the shear opening and falling from the shear upon the rolls at one end of the shipping department. Here it is weighed and carried by a long overhead travelling crane—furnished with several trolleys, which lifts the long plate in such a manner as to prevent bending by its own weight—directly into the car for shipment, or into its proper place in the shipping warehouse.

At the Lukens Works, a straightening arrangement has recently been adopted, whereby plates, as they leave the rolls, and while still red hot, are passed through and back until the surface is changed from

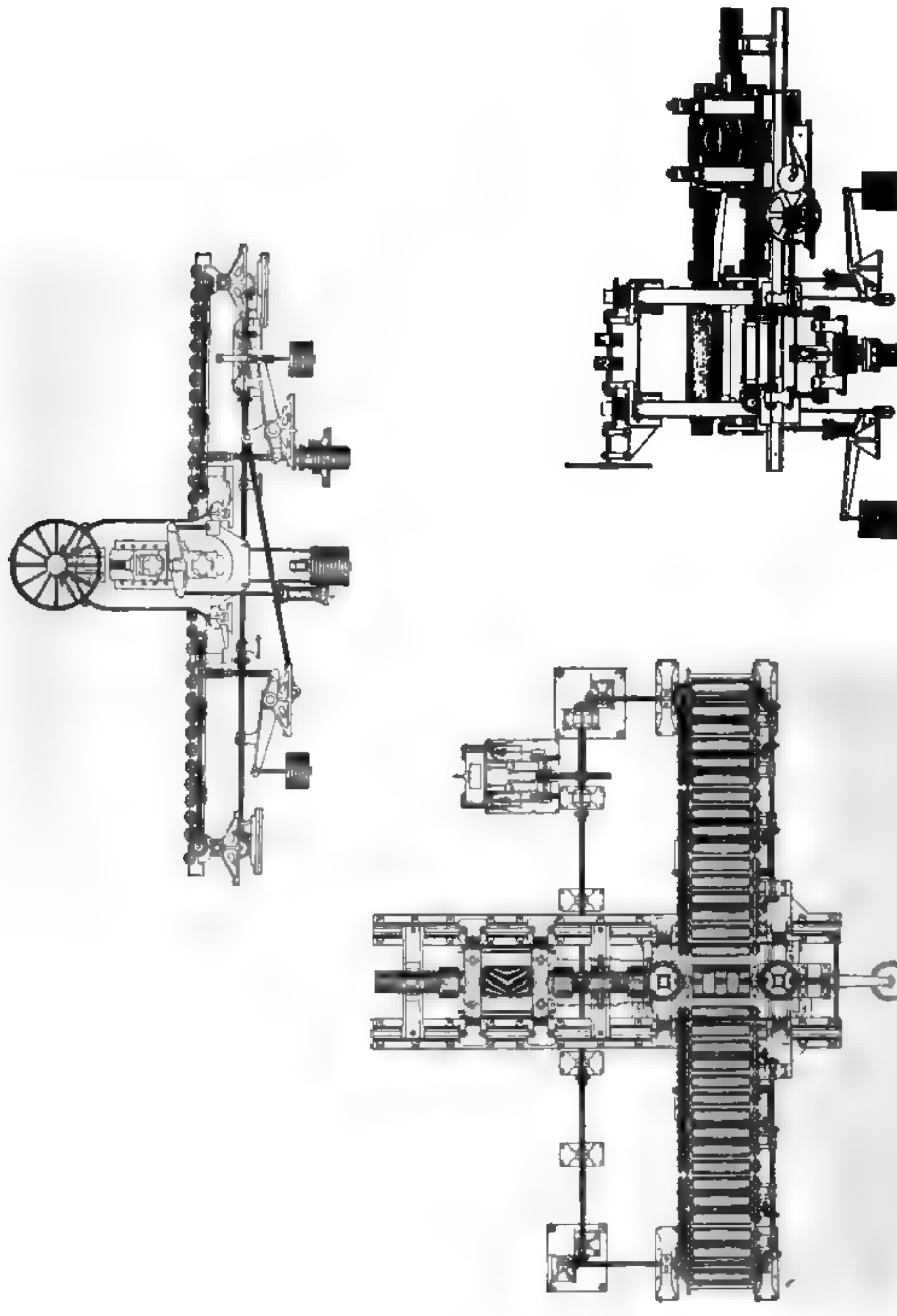


FIG. 30.—DETAILS OF THREE-HIGH PLATE MILL.

a buckled to a flat one. This system is applied to boiler plates only. The machinery consists of seven rolls grouped together, and so adjustable that plates of practically any size can be rolled. The same type of straightener with 11 rolls is used to straighten the thinner gauges, No. 10 to ¼ in.

The following is a summary of the different brands produced at the Lukens Works :—

	Tensile Strength.
Extra Soft Steel	45,000 to 55,000
Extra Locomotive Fire-box Steel ...	50,000 to 60,000
Fire-box Steel	52,000 to 62,000
Marine Steel	50,000 to 60,000
Flange Steel	52,000 to 62,000

The Works of Messrs. Worth Brothers.

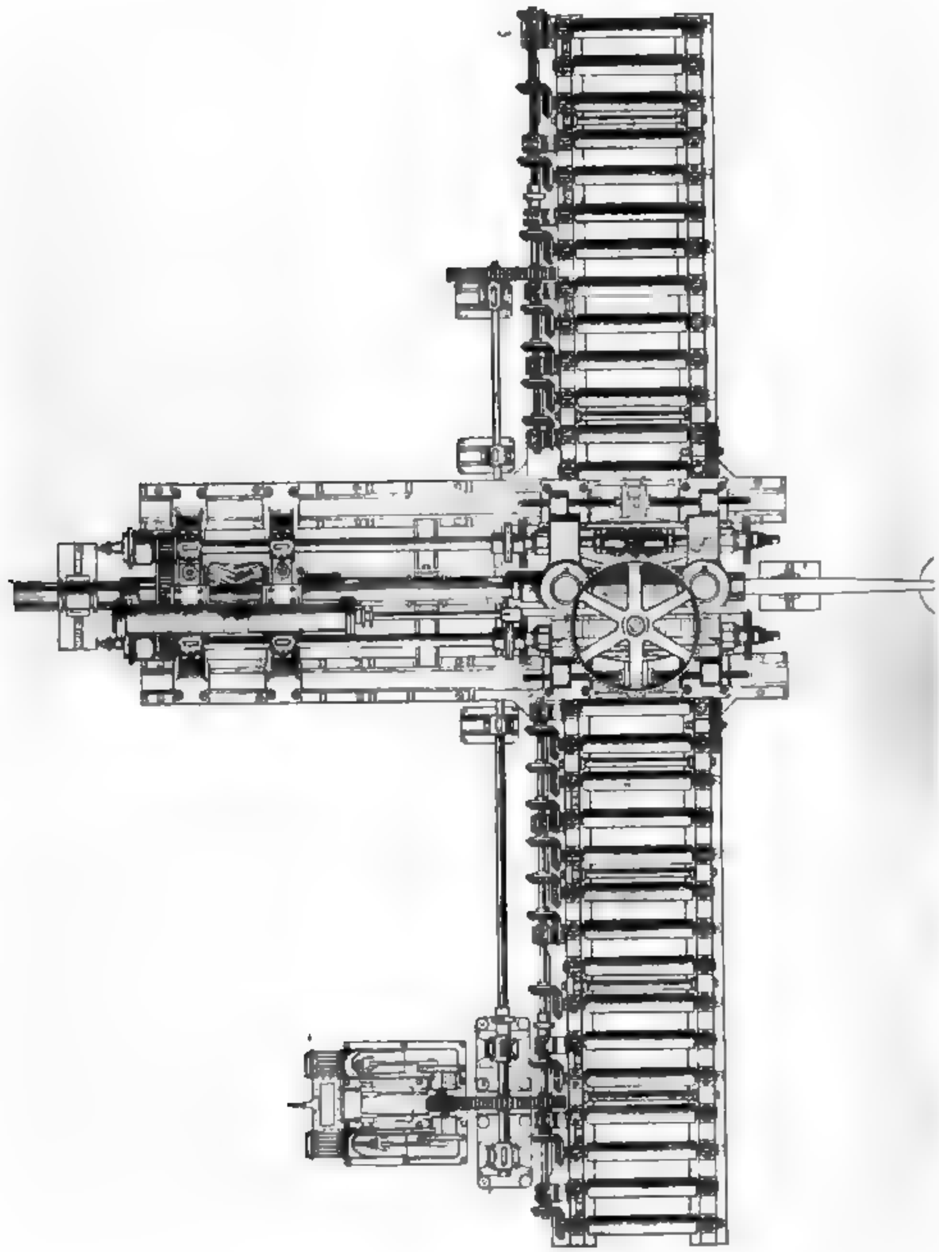
These works, like those of Lukens, produce basic steel from a pig which averages 1·0 per cent. P., 1·0 per cent. silicon, and ·05 per cent. sulphur, got from Valley Works twenty or thirty miles distant. The furnace plant consists of four basic and two acid open-hearth 40-ton furnaces. The principal plate mill is claimed to be the largest in the country. It has turned out in one week 1,493 tons of sheared plates from ¼ to 1½ in. thick, mostly boiler plates for locomotive purposes. The manager informed me that he expected to get it up to 1,750 tons per week. The rolls are 132 by 36; the mill is three-high, the middle roll being 22 in. diameter. It is driven by a Corliss engine, 42 in. cylinder by 68 in. stroke. The largest size of plate produced has been 17,000 lbs., $\frac{5}{8}$ in. thickness, and 80 in. by 66½ in. The mill can roll plates 126 in. wide. The mill rolls only ingots as a rule, but rolling slabs would give 800 tons a week additional output.

For the basic bottoms of the open-hearth furnaces, Messrs. Worth, as at the adjoining Lukens Works, use limestone, dolomite and magnesite. The greatest output hitherto got from the open-hearth plant was 1,168,000 lbs. of acid steel, with 15 heats, in one week, and 2,037 tons from five furnaces. The basic furnaces run from 730 to 937 tons per week. The Wellman charging machine is used—one for six furnaces.

Limits of Universal and Bar Mills.

One of the Carnegie Company's engineers has stated that in the American practice, the ingot is first reduced to a slab in the slabbing mill, the slab as a rule being reheated, and then rolled flat to the required width and thickness in a plate mill. Plates having a width of over 48 in., or less than ¼ in. thick, are rolled in an ordinary plate mill—that is, one having only horizontal rolls—and plates rolled in such a mill must have their edges sheared in the direction of the length of the plate, subsequent to rolling and straightening. Plates under 48 in. in width and over ¼ in. in thickness do not need shearing, as true edges can be obtained in a mill having, besides the same horizontal rolls as the plate mill, a set

of vertical rolls. Plates 6 in. and less in width are worked in grooves cut with the rolls similar to those for shapes, and can be rolled



in the same way as shapes. It being a less expensive process, most bars are rolled in the same manner.

Some Plate Mills.

Two of the largest plate mills in the United States are those of South Chicago and of Homestead—the former put in operation in 1896, and the latter transferred from the Bethlehem Company's Works at South Bethlehem, to the Homestead Works of the Carnegie Steel

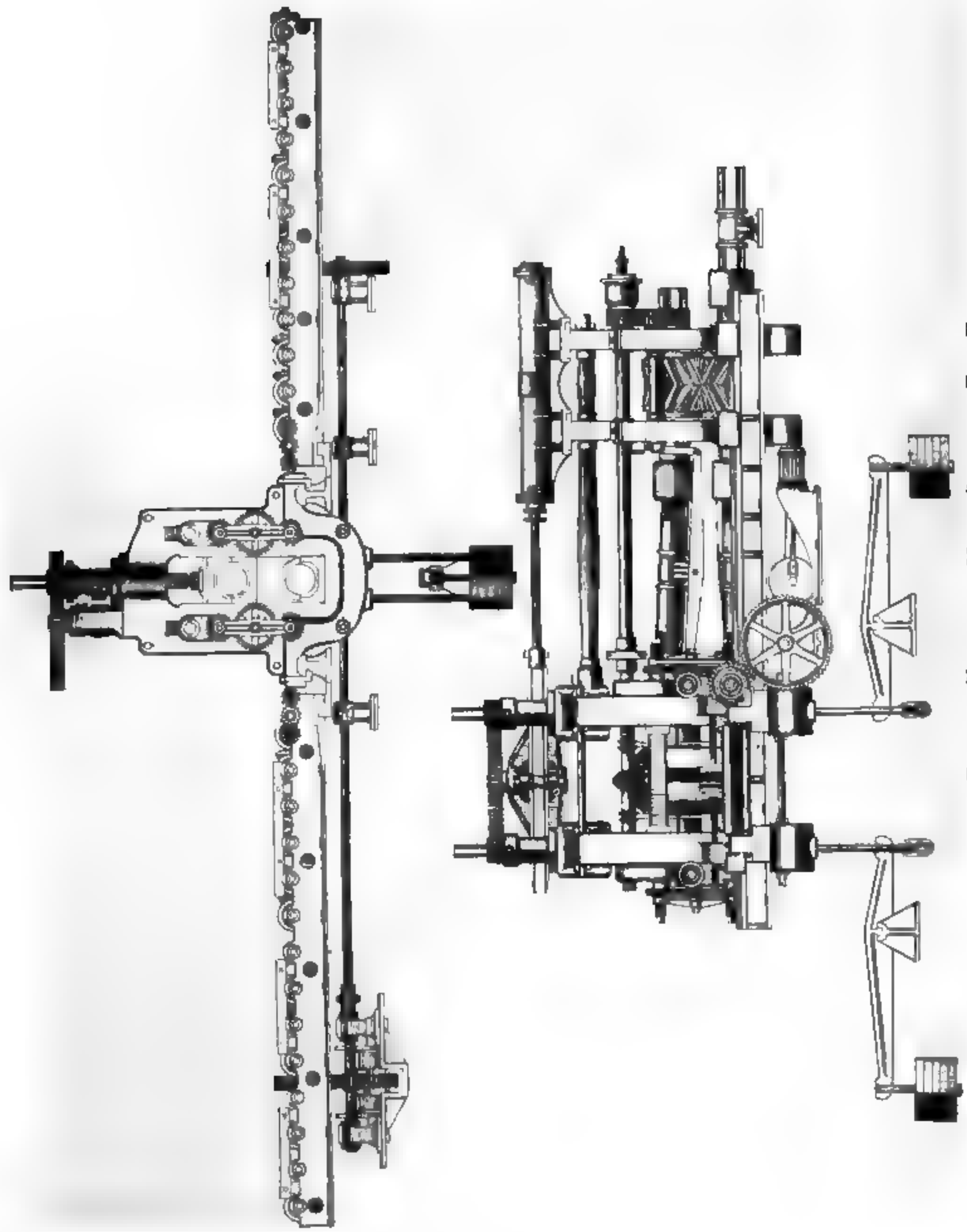


FIG. 32.—UNIVERSAL MILL—SIDE AND END ELEVATIONS.

Company only a year or two ago. At the time of erection each of these mills was considered the finest one of its kind in the United States. The South Chicago mill has two stands of rolls, three-

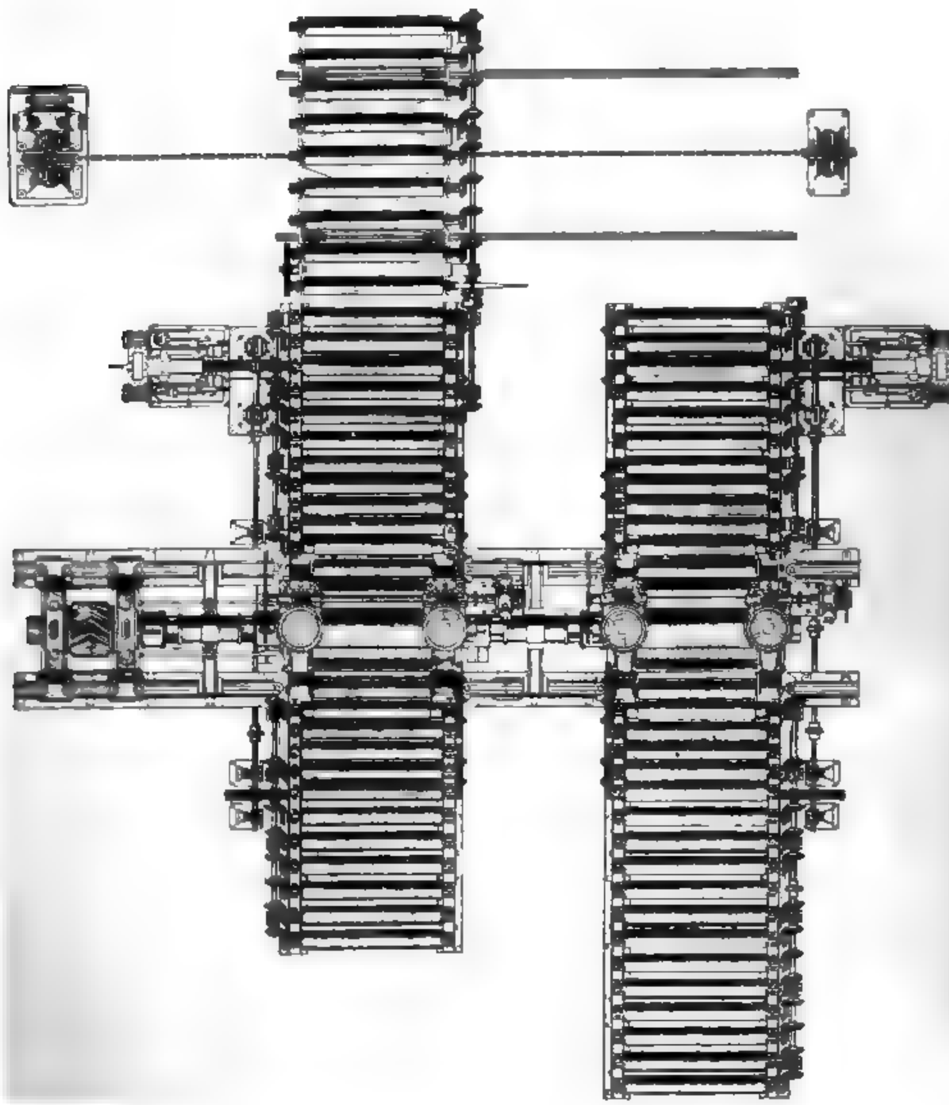


Fig. 33.—Reversing Plate Mill—Plan.

high, the first 90 in. long, top and bottom rolls 34 in., and the centre rolls 18 in. in diameter. The outer stand has 132 in. rolls, top and bottom rolls 34 in. diameter, and centre roll 21 in. in diameter. The Homestead plate mill has 32 in. slabbing rolls, three-high 34 in. plate rolls, with 34 in. upper and lower, and 20 in. middle rolls. The width

of the rolls is 128 in., and the mill is equipped with three 132 in. and two trimming shears.

Illustrations are given herewith of a number of typical American rolling mills. The three-high plate mill illustrated (Fig. 30) is the

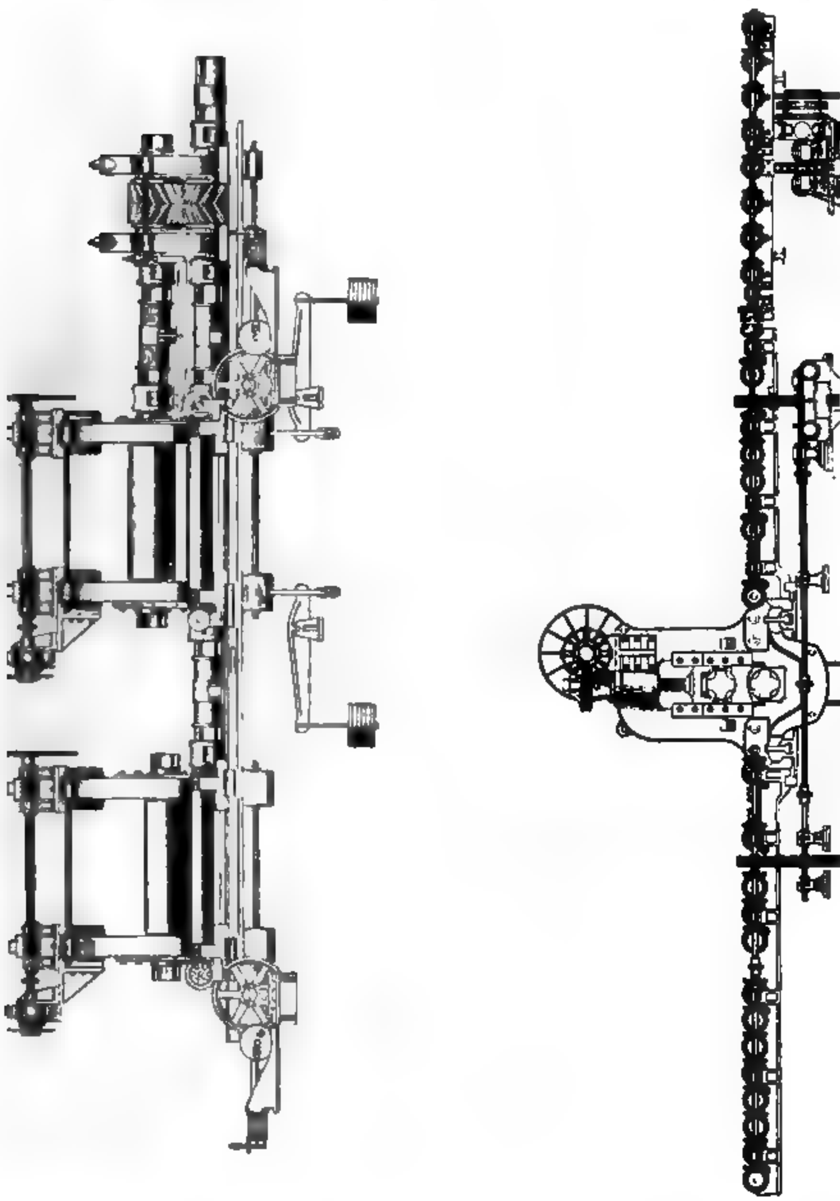


FIG. 34.—REVERSING PLATE MILL—SIDE AND END ELEVATIONS.

standard American type, and may be seen at work at Homestead, Lukens, Paxton, Carbon Steel Works, Carnegie Steel Company's Lower Union Mills, the mills of Park Brothers & Company, and other plants of

leading position. It is claimed that the feature of the mill, which gives a smaller middle roll, facilitates the better reduction of the size of the piece being rolled than would be the case in mills with two rolls of larger diameter.

The type of universal mill shown herewith (Figs. 31 and 32) is

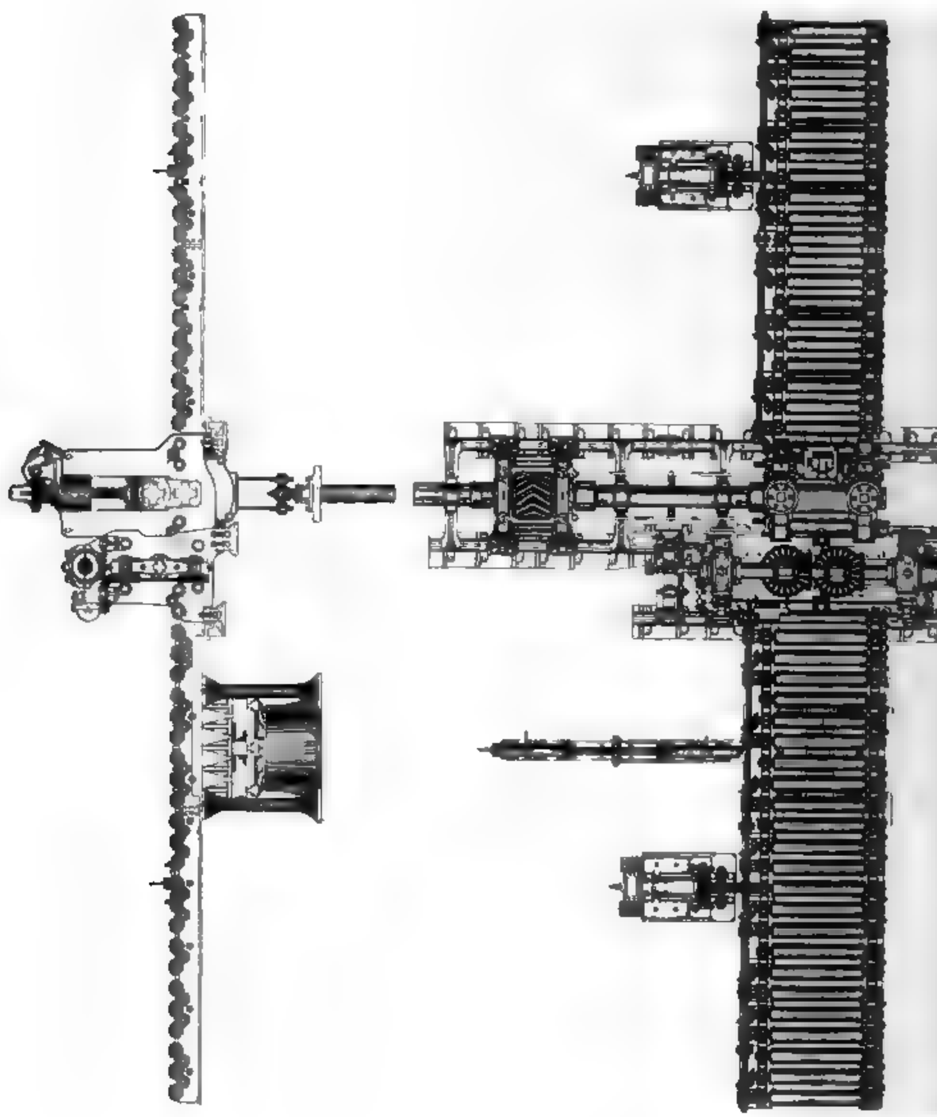


FIG. 35.—SLABBING MILL—PLAN AND ELEVATION.

usually employed for rolling plates of special sizes, and more particularly when long and comparatively narrow, varying from 8 to 42 in. wide, and above ¼ in. thick. The makers claim that for such plates

this mill is "indispensable, as it finishes plates with square and straight edges, not requiring any shearing."

The reversing plate mill shown herewith (Figs. 33 and 34) is one that is known to American steel manufacturers as employing two pairs of rolls—roughing on one set and finishing on the other—the roughed-

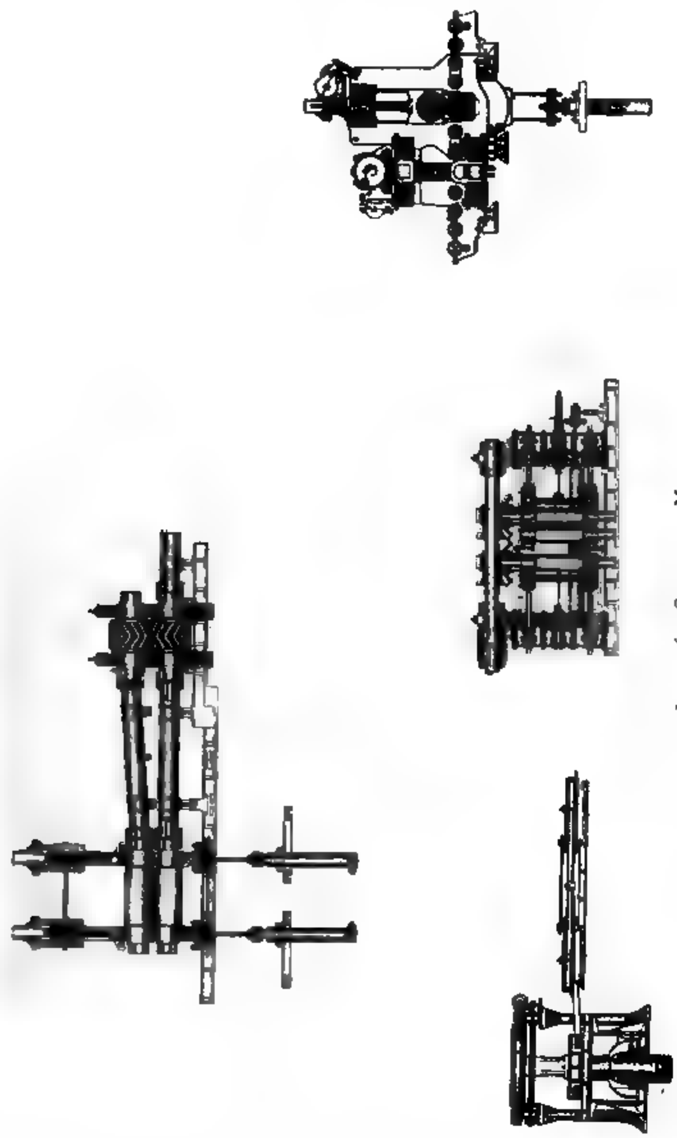


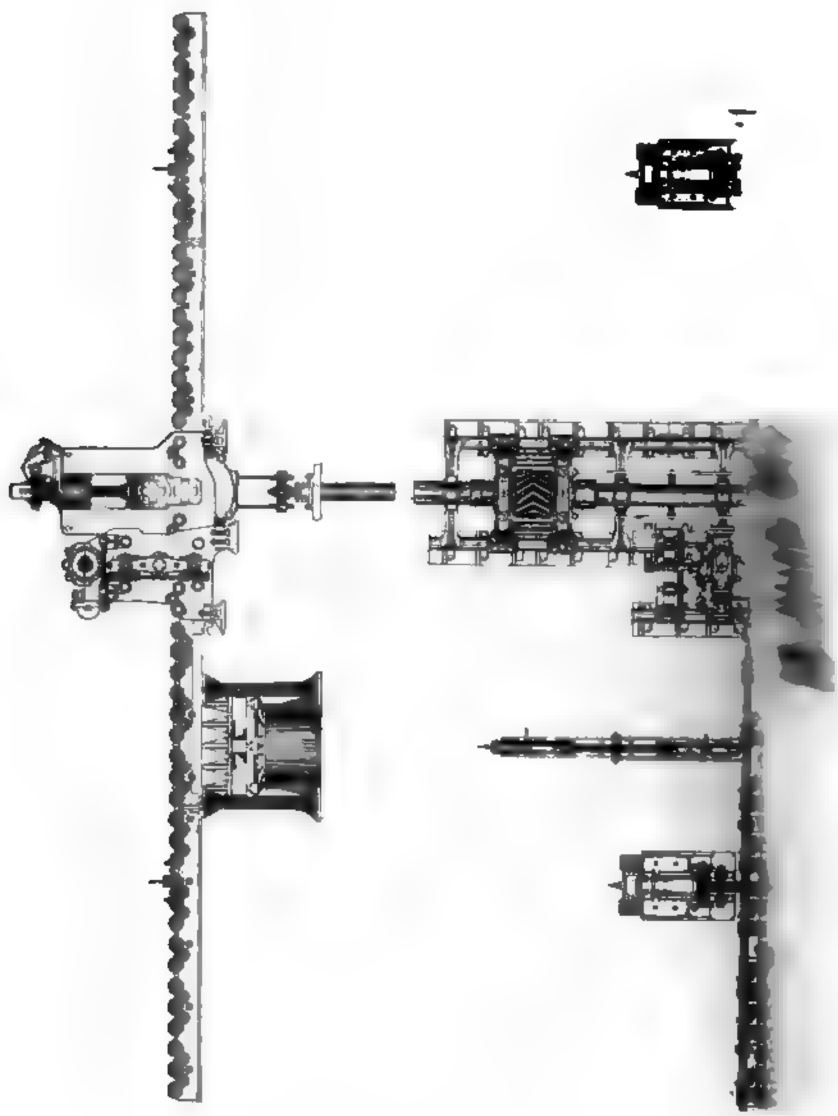
Fig. 36.—Slabbing Mill.

down plate being transferred by power from the table of one pair of rolls to those of the other. The makers recommend this type as having, for some purposes, advantages over the ordinary three-high mill.

Another type of mill of which Messrs. Mackintosh, Hemphill & Company have supplied quite a number is the slabbing mill shown

leading position. It is claimed that the feature of gives a smaller middle roll, facilitates the better reduc— of the piece being rolled than would be the case in mi of larger diameter.

The type of universal mill shown herewith (Fig.. .



usually employed for rolling plates of special sizes, and n larly when long and comparatively narrow, varying from wide, and above ¦ in. thick. The makers claim that for

the more extensive use of steel in general building operations, to the large and rapid replacement of old wooden trestles by new steel bridges and viaducts, and to the expansion of many kindred uses, has advanced, and is advancing, at such a notable pace, that not a few look forward to the absorption of all the structural steel that can be produced for at least a year or two to come, in meeting the urgent needs of the United States. On the other hand, the new plants and the further extension of old ones must greatly increase the capacity for production. I have before me a list of five new works of importance that have just entered upon the manufacture of bridge and structural steel generally, and of twelve other established works which have more or less consideraby extended their existing plants, whereby the output of structural steel will be vastly increased.

The Pencoyd Works near Philadelphia.

The American bridge-building works have of late years made a considerable reputation in securing contracts in outside markets, not only in reference to the low cost at which work has been undertaken, but also in respect of the extraordinarily short time within which they have undertaken to complete contracts of this description. Their competition in work of this sort is not, however, so recent as is generally supposed. It is a good many years since they secured and executed the contract for the Hawkesbury River bridge in New South Wales, and they have taken occasional contracts since then in competition with both British and German manufacturers. There are now a number of large works in America laid out for such work and possessed of resources that enable large outputs of structural steel to be provided for.

I had the choice, while in Philadelphia and Pittsburg, of paying visits to several of the leading bridge-building establishments, but I decided, for reasons that will be tolerably well understood in England, to devote more time to the Pencoyd Works, near Philadelphia, in preference to the others. This establishment has of late attracted a good deal of attention in Europe, partly because of its success in tendering for the Atbara bridge and other important contracts, partly because of the manner and character of its equipment and resources, and partly because it has been the first concern in the United States to take up and apply the Talbot process of producing open-hearth steel. It has other claims to notice which need not be dwelt upon.

Accepting the invitation of Mr. James Christie, the engineer and manager of the works, I spent a day at Pencoyd with much interest and profit. A glance at the illustration accompanying these notes will show that the works lie along the Schuylkill River, less than 10 miles from Philadelphia. The various departments begin, at the lower end, with a large open-hearth furnace plant, and thence follow in order the axle forge, the eye-bar mills, the straightening and cutting departments, the mill office—almost in the centre—the rolling mills and the machine shop, the shops where girders, beams, etc., are punched and finished and laid out, the hydraulic forge, the bolt and rivet shops, and the stock yard. The area occupied by the works is about a mile in length, but comparatively narrow in width.

Naturally, I began my inspection of the works at Pencoyd by going over the melting department, which embraces ten 30-ton open-hearth furnaces of the usual type, and one Talbot furnace, which has been in more or less constant work since it was started on the 14th of September, 1899, so that at the date of my visit in October, 1901, it had been about two years in operation.

The manager of the melting department informed me that the capacity of the Talbot furnace was taken at 100,000 lbs. of metal, and that it was their practice to tap out 30 tons and leave in 20 tons. Sandless pig is used because it is found that it is more susceptible to heat, and melts more rapidly than pig which is not machine-cast. The Talbot furnace gives about 42 heats in 24 hours, using molten metal. The hands employed at the Talbot furnace are—one melter, two chargers, one first helper, and one second helper. For each of the other furnaces there is one melter (for two), one charger, one first helper and one second helper.

At the time of my visit the largest week's work done in the Talbot furnace had been about 800 gross tons, which, if maintained over the year, would give a total annual product of about 42,000 tons. This was done charging pig-iron alone into the adjoining cupola by means of a Wellman charging machine, which is also used to charge the mill scale, ore, and basic additions to the plant generally. In the Talbot furnace there is, of course, a very quick reaction. In 11 minutes 80 per cent. of the carbon and phosphorus has been taken out, and in 15 minntes practically the whole has disappeared.

From several sources it has been suggested that the Talbot furnace involves a heavy cost for repairs, which minimises whatever other advantage it may possess over the ordinary open-hearth. I discussed this matter both with Mr. Christie and the manager of the open-hearth department, and was assured that the cost of repairs is not appreciably greater than in the ordinary type of furnace.

At Pencoyd the materials enter the works at a different level to that of the charging platform, and are raised to that level by elevators, the cupolas being alongside. The charging platform is wide and roomy, and about 400 ft. in length. I was informed that the steel works as a whole had cost about 7,000,000 dols.

The principal mills at Pencoyd are one 28-in. and one 23-in., on the combined two-high and three-high systems. One of these mills has produced over 3,500 tons of structural steel per week. The passage of the ingot through the rolls up to its conversion into a finished girder is one of the most perfect and economical mechanical operations that I have ever witnessed. The live rollers are so contrived that there is not a moment lost, and no hand labour to speak of is required. I counted one man at the engine, one roller, two men at the tables, and one extra helper, making five hands in all, while the mill was working at the rate of about 1,000 ft. per minute, and producing 2,500 to 3,000 tons per week. Not less remarkable is the rate of production of the other mechanical appliances employed in cutting, punching, rivetting and otherwise finishing the girders and beams produced. At one machine, Mr. Christie informed me, in the smallest size of

beams a hundred cuts per hour have been made for a whole day. In heavier beams the cuts will average about 40 per hour, or over 300 per day per machine. In 6-in. to 8-in. beams, about a thousand cuts are got in the ten hours at the hydraulic beam shears. This shears has taken the place, and now does the work of, three cold saws. This machine is typical of the capacity of the equipment generally.

I was much struck with the bridge shop, which is 200 ft. wide, by 260 ft. long, in which all the punching, shearing and straightening operations are done. Everything that can facilitate the passage of the girders and beams from the mills to the rivetting machines, and thence to the stock yard, appears to have been thought of—so much so, that Mr. Christie gave me the output of this one shop at an average of 6,500 tons per month of finished girders, although he added that they had produced as much as 8,000 tons in one month. While this appears to be an almost incredible output for a shop of the size named, it is not difficult of comprehension by those who have witnessed the despatch with which the work is got out of hand. The machines employed have been mostly designed and supplied for this work by Mr. Christie, and their general capacity may be illustrated by the fact that one of the punching machines, which I watched for some time, punches 1,500 holes in one hour, and manipulates four girders at the same time, being spaced with ample adjustment. Among other details of importance it may be noted that the work is handled by magnets, that every machine has its own electric motor, and that most of the machines are placed on turntables so as to have the work always straight.

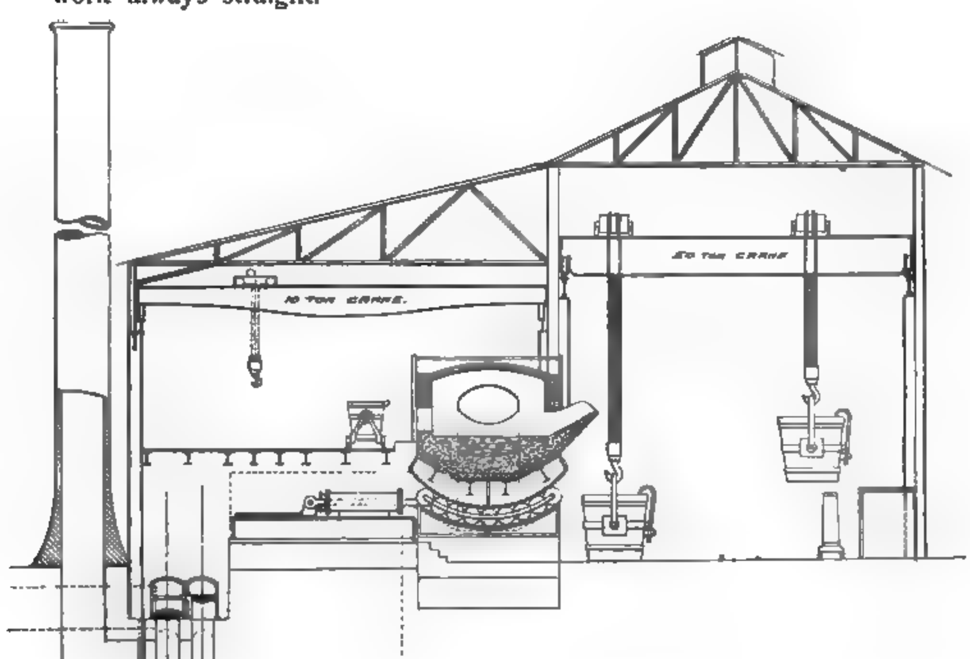


FIG. 37.—END VIEW OF A TALBOT OPEN-HEARTH PLANT.

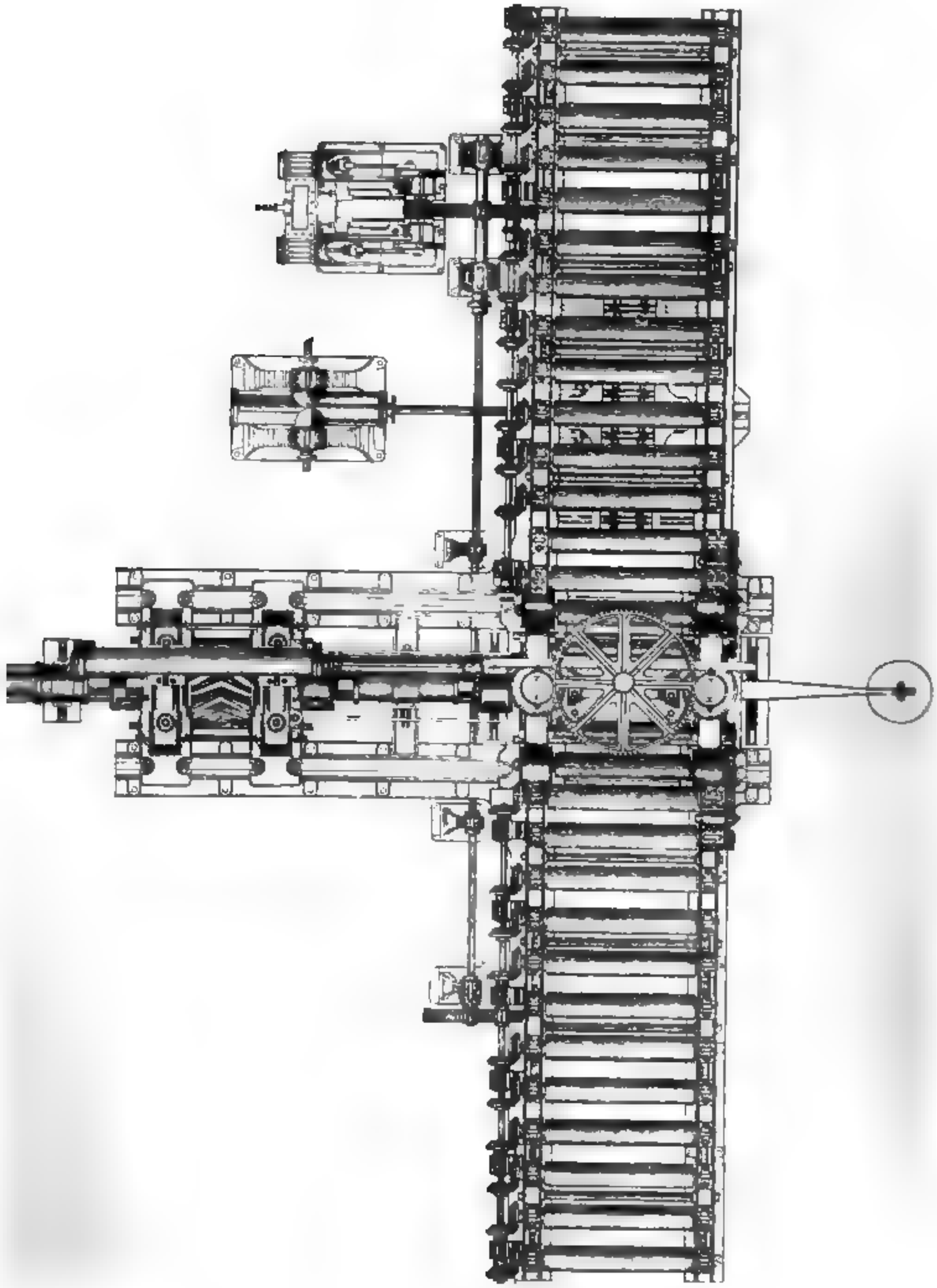
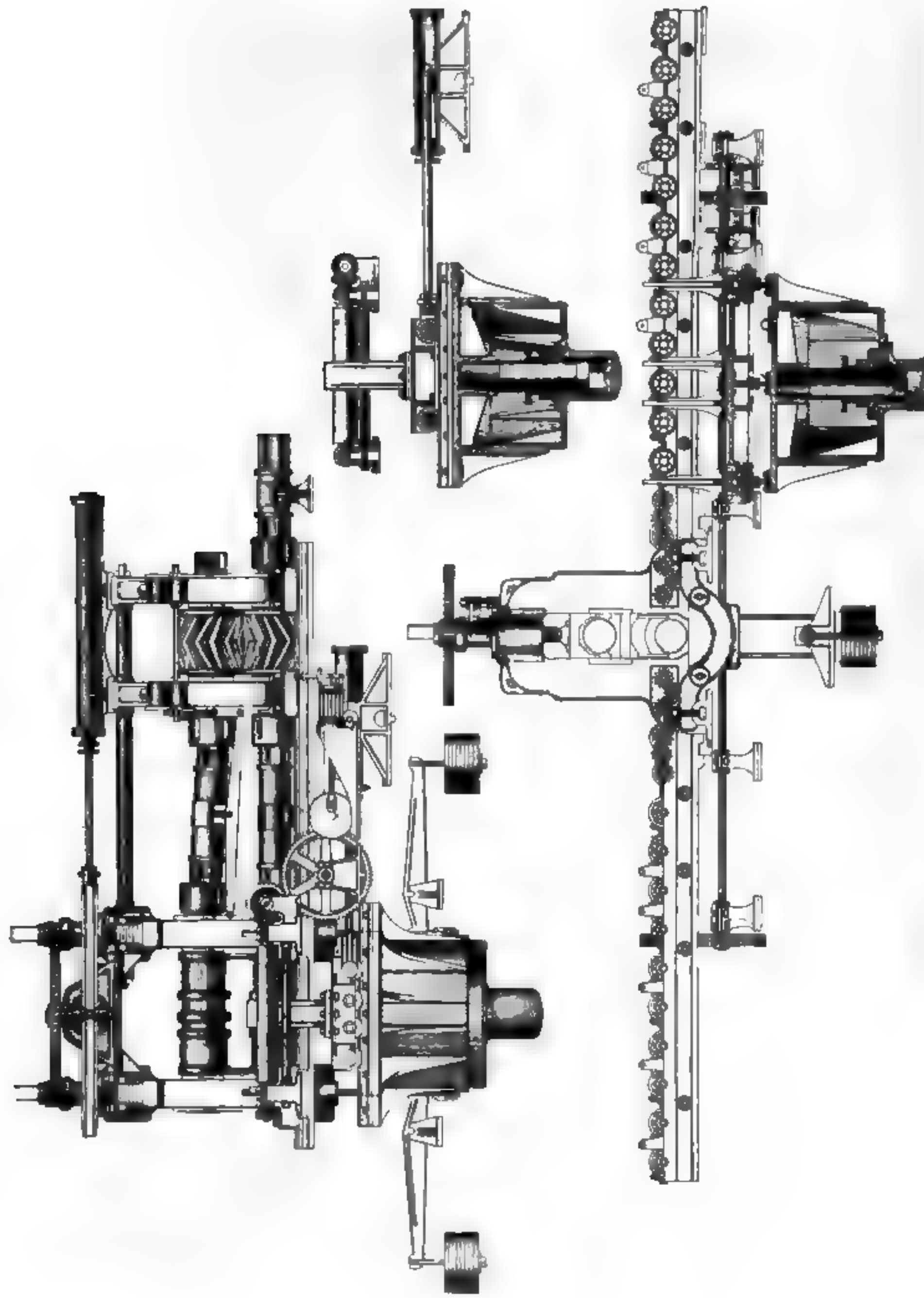


FIG. 38.—REVERSING BLOOMING MILL—PLAN



Among the auxiliary departments at Pencoyd, mention may be made of an eye-bar plant, at which a special hydraulic upsetting machine produces from 40 to 100 heads in the day of nine hours, according to the size of the bars, the average of the 8-in. size being about 40; and a roll-turning plant, including nine lathes—each having its own electric motor—which turns out on an average about two sets of rolls of the largest size per week. As regards the latter, it may be of interest to add that at Pencoyd they appear to prefer steel to chilled iron rolls, and Mr. Christie informed me that the use of steel rolls had increased of late to such an extent that more than one-half of the whole are now of that metal. The steel used is specially hard-grained with high carbon. Naturally, in a plant producing such a large variety of sections, the stock of rolls is very large, the largest being 18-in., although until lately 24-in. were used.

The systematic way in which every stage of manufacture is provided for in the most economical possible manner is one of the most striking features of the Pencoyd Works. As one of many evidences of the same kind it may be mentioned that while material is moved longitudinally through the shops on trollies, and transversely by electric cranes, it rests almost entirely on skids, and its progress and treatment are much assisted by the liberal use of automatic multiple punches, guides, skids, and other economical devices. Most of the large machines for shearing, punching, etc., are placed on turn-tables so that they can be operated in any position, and the movement of plates is facilitated by roller frames and goose-necks.

It would be possible to add much more to my notes on this important establishment, but I can only give space to say that the works receive their pig-iron from different blast furnace plants within a limited radius, and their coal from collieries within 50 miles. The works are not exceptionally well placed with regard to either; neither have they specially excellent means of transport, as the Schuylkill River is not of much use to them, owing to its shallow depth, and the bulk of their material has to be moved by rail, even for foreign shipment. It did not strike me in going round Pencoyd that there were any advantages, appliances, or methods that could not easily be equalled, and, on a green field, even excelled, at home. At the same time, with some knowledge of British plants, including bridge-building establishments, I am bound to add that a great change will be required to enable our home concerns to go one better.

Since my return from the United States, a paper mainly devoted to the Pencoyd Works has been under the consideration of British civil engineers,* in which it was shown that the output in gross tons per man per annum averaged 771 for draughtsmen, 115 for men in bridge-shop, 185 for men on eye-bars, and 2,366 for templaters. These figures are likely to be useful as a standard of comparison in British work.

The same writer, referring to our home practice, remarked that "the saving which was possible by systematic methods in the drawing-office, and the use of stops and guides and multiple punches, so as to reduce the templating, was very great. Small portions of the

* "American Workshop Methods in Steel Construction." Paper by H. B. Molesworth, read Jan. 14th, 1902, before the Inst.C.E.

work should be made interchangeable and turned out without having to mark each piece. The use of the spacing-punch obviated the necessity for wooden templates, and for marking."

Among the features of the Pencoyd Works, specially noted by this writer, he names the following:—

"Plates were handled under punches by roller frames or goose-necks and moved by a chisel bar working on a fulcrum. Rimering was done by gantry-drills, which resembled a Wellington crane with eight radial drills on it. Pneumatic drills and rivetters, and chipping-machines of the Boyer type were much used, and bad holes, which were very uncommon, were rimered and not drifted. Ends of long pieces were rimered or drilled by compressed air drills, fed up to the work by a compressed-air cylinder behind them. Large plate-girders were rivetted by hydraulic gap rivetters mounted on a ram to raise or lower them, the work being suspended from an electric Wellington crane traversed by a switch on the rivetter platform. Ends of members were milled by rotary planers which had heads 4 ft. 6 in. to 6 ft. in diameter, with cutters fixed near the periphery. Angle-stiffeners were bevelled in pairs in a milling-machine with fast vertical feed, and fitted perfectly. Large joists or channels were handled with clip-hooks furnished with chisel points.

"Very little planing was done in the works; 'Universal' plates were used, and were rolled by nearly all American plate-mills without extra charge."

The chief causes of cheap working in America are summed up as follows:—

"1. The workmen, though more highly paid than in England, turned out a much larger quantity of work.

"2. The arrangement of the works was more carefully thought out, and labour-saving appliances were more used.

"3. There was more method, and probably more scientific knowledge, in the drawing-office.

"4. The works were run night and day.

"5. The templating was reduced to a minimum by care in the drawing-office and by the use of automatic machinery and stops and guides.

"6. Obsolete machinery was turned out of the works as soon as it was superseded by anything better.

"7. All tools were kept in a state of perfect efficiency."

Bridge-building Resources.

This may be an appropriate time and place to call attention to the fact that a very considerable proportion of the bridge-building plants of the United States are under the control of the American Bridge Company, which is one of the constituent companies of the United States Steel Corporation, and which has a capital stock of 70 millions of dollars. This company has only one steel-manufacturing plant, that of Pencoyd, and only one set of rolling mills, that established at the same works. But they have no fewer than 25 separate bridge-building plants in different parts of the United States, with a total capacity stated at 441,200 tons of bridge work annually, including Pencoyd, which alone has a capacity of 65,000 tons. No other bridge-building concern is on the same scale as Pencoyd. The two next largest concerns are the Keystone Bridge Works in Pittsburg, and the American Bridge Works at Chicago, each of which has a capacity stated at about 32,000 tons, and other exceptionally important works are those of the Shiffler Bridge Works, in Pittsburg, the Trenton Ironworks, in New Jersey, and the Edgemoor Bridge Works, at Edgemoor, Delaware. At a number of the leading bridge-building works, they have considerable plants for the manufacture of bolts, nuts and rivets.

D.—THE MANUFACTURE OF TUBES.

The manufacture of tubes has within recent years become a great industry in the United States, and presents every appearance of becoming much greater within a very short space of time. At the present time there are six or eight considerable tube plants being built in that country, and it is expected that the whole of these will be at work next year. This will be likely to add from one-third to one-fourth to the existing capacity of the United States, which is now nearly one and a half million tons per annum.

The explanation of the enormous expansion of the tube industry of the United States within recent years is, *mutatis mutandis*, the same as that which has brought about a large development of the tube industry of Scotland, Staffordshire, etc. The increase of demand for tubes for telegraphic, telephonic, hydraulic, and kindred purposes, would have led to a large development in any country with claims to civilisation, but in the United States the great areas to be covered have accentuated the demand.

The National Tube Company's Works.—There appears to be no reliable record of the total tonnage of tubes and pipes produced in the United States. The total annual capacity of the 14 wrought-iron and steel pipe and tube works belonging to the Steel Corporation is returned at 922,000 gross tons, but the capacity of the independent plants built and building cannot be far short of another million, although this latter figure is put forward with all reserve.

The total capacity of the National Tube Works at McKeesport is 430,000 tons of pig-iron, 240,000 tons of wrought iron and steel skelp, 13,500 tons of charcoal blooms, 330,000 tons of Bessemer ingots, and 285,000 gross tons of pipes and tubes from $\frac{1}{8}$ in. to 30 in. inclusive. The National Tube Company embraces several other plants with large capacity of output, including the Pennsylvania Departmental Works, Pittsburg, with a capacity of 120,000 gross tons; the Riverside Tube Works, West Virginia, with a capacity of 95,000 tons; and the Chester Works, Delaware County, with a capacity of 50,000 tons.

The largest existing works in the United States are those of the National Tube Company at McKeesport, about fifteen miles from Pittsburg, which I visited, by favour of Mr. Schwab, and with the manager of which, Mr. G. G. Crawford, I had an interview. With these works are associated others that produce the iron and steel used in the tube manufacture, beginning with the Monongahela furnaces, which are really part of the same plant, and including the steel works, also close at hand, of the same name; and the Boston Iron and Steel Works, about two miles distant, in the same valley. The National Works employ about 8,000 hands, and produce over 1,100 tons per day of tubes of all kinds.

Except in regard to their magnitude, it did not strike me that the National Works, although by far the largest works of their kind in the world, and enjoying all the advantages that belong to production on a large scale, were equal in arrangement and in the conditions that make for economy in such a plant, considered by itself alone, to some of the tube mills that I have been over in Scotland. Generally

speaking, the works strike one as being unduly crowded, and there is a lack of that method and order about them which one expects to find in a plant of the most modern type. Both Bessemer and open-hearth steel are used in tube production. The Bessemer is produced on the spot, two converters being employed. The open-hearth steel is purchased. A puddling forge is also carried on at McKeesport.

The situation of the works in reference to the supply and cost of raw materials is much the same as that of the works of Pittsburg. The coke used in the blast furnaces is from Connellsville, 45 miles distant; the ore used is Lake Superior. The blast furnaces are new. Their best average had been 400 tons per day per furnace at the time of my visit. The general design and arrangement of the blast furnaces are much the same as those of the Edgar-Thomson Works, on which they have been largely modelled. A casting machine is used, so that sandless pig is produced. The blast furnace manager informed me that this description was perfectly well suited to the requirements of the concern.

The tube department is equipped to produce practically all sizes with their usual fittings—the sizes generally manufactured varying from ⅛ in. up to 30 in., while any special joint that may be specified is provided. The output is of both butt and lap-welded tubes.

The plant employed has naturally a few features more or less exceptional, and, perhaps, peculiar to itself. Its general features, however, are much the same as those of a well-equipped British works, apart from its magnitude. The feature that struck me most forcibly was the resistless energy with which the work was turned out, all the machines being worked for all they were worth. The heating furnaces are of the usual type. The bending furnaces heat about 1,700 tubes of the smaller size and 2,000 of the larger size per day. From the heating furnaces, the pipes are run along V-shaped live rollers to the welding furnaces and thence to the cold rolls. The furnaces are generally of the same size. The strip is bent in long rolls, adapted to take any size that may be called for, by an ingenious application of a descending top roll. The edges of the pipes so formed are hammered down by several men, who then pass them on to a second furnace. The average output of these shaping rolls was given me as 250 18-in. pipes per day. The furnaces are generally built in pairs, rolls between. Electric power is used for actuating all the machinery to which it can be applied.

There are six furnaces for butt and twelve furnaces for lap-tubes. The furnaces are gas-heated, Duff's producers being used. Instead of rolls, the tubes are in some cases drawn through two bells, made of cast iron, and which appear to answer very well. The company have special machines for swaging the ends of the pipes. The works are run on the two-shift system. Both piece work and day wages are paid. It may be added that the workmen generally live in the town of McKeesport (which is known as the tube town, and has a population of 15,000 to 20,000) and close to their employment.

The McKeesport Works of the National Tube Company are easily the first in the world for capacity of output. In January last they

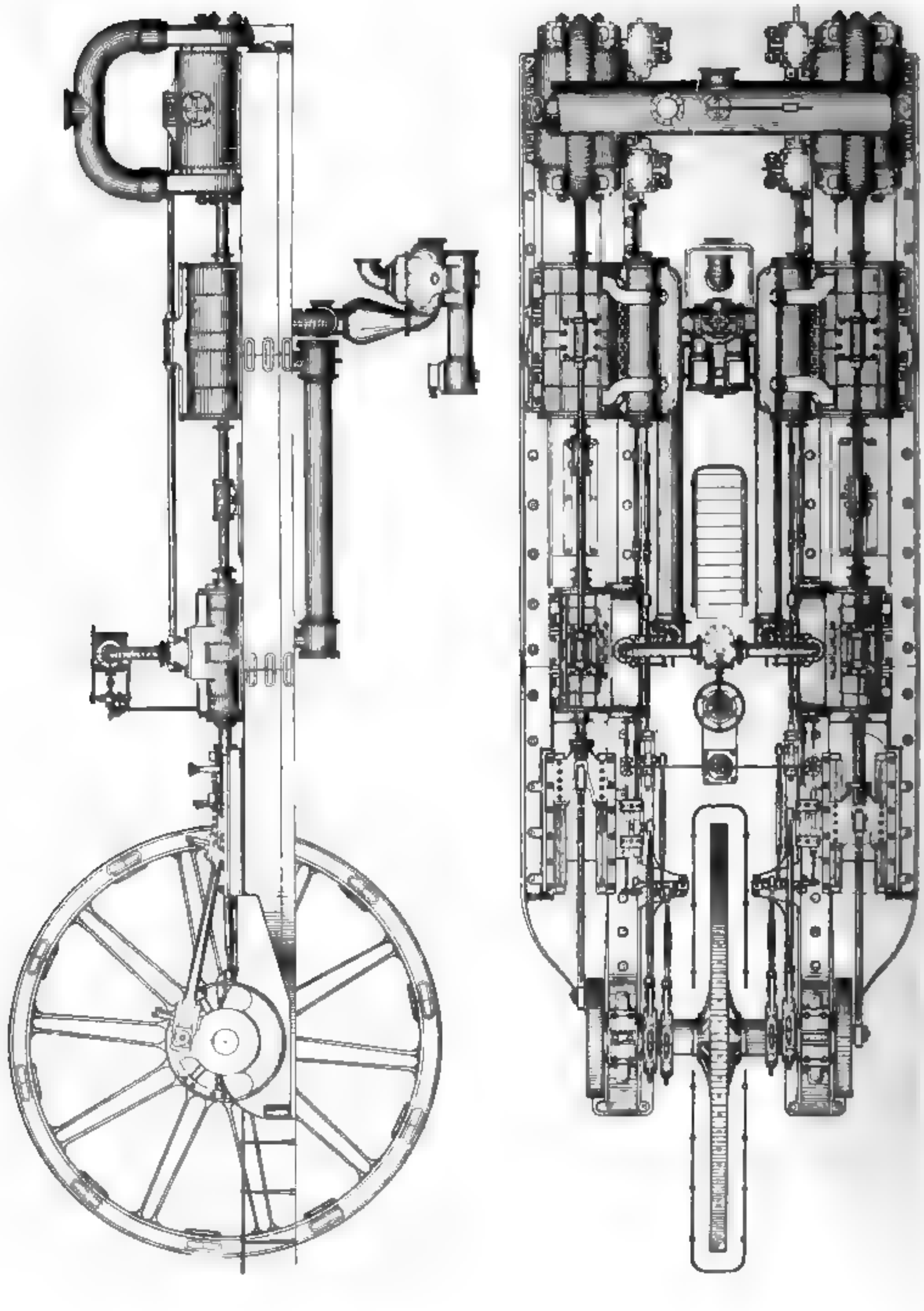


FIG. 40.—COMPOUND CONDENSING BESSEMER BLOWING ENGINE AT NATIONAL TUBE WORKS, MCKEESPORT.

turned out 30,551 tons of finished pipe, which is at the rate of over 366,000 tons a year. The best record previous to this was 28,882 tons in one month.

The export of tubes is now a considerable business in the United States, mainly by the National Tube Company, which, in January 1902, is reported to have shipped to various countries nearly 3,000 tons of pipes. The tonnage manufactured at McKeesport has to be transported by rail to either Philadelphia, which is nearly 400 miles, or to New York, which is nearly 500 miles distant.

After the National Company, one of the most important corporations in the United States engaged in the tube industry is that known as the Shelby Company, which, although a constituent of the United States Steel Corporation, retains its distinctive name, and is operated by a distinct management. The Shelby Company carries on seven different seamless drawn tube works, with a capacity for the production of 63 million feet of tubing. It also carries on five rolling mills, with a capacity for producing 44,600 tons of blanks annually. The most important individual establishment is the Shelby Works themselves, at Richmond County, Ohio, which are equal to an output of 12,000 gross tons of blanks annually and 24 million feet of seamless drawn tubing.

New Tube Plants.

The bulk of the tube-producing works now in operation in the United States are owned by or connected with the National Tube Company. This concern has now under its control nine rolling mills and steel works, capable of producing 480,000 tons of Bessemer ingots, 435,000 tons of slabs and billets, and 503,000 tons of skelp annually, with 36,000 tons of plates and sheets. It also controls fourteen tube works, with an annual capacity of 922,000 tons of pipes and tubes, in addition to two seamless pipe and tube works, whose capacity is not stated by Mr. Swank.

From Mr. Julian Kennedy, of Pittsburg, and other authorities, I obtained information as to new establishments recently erected, or now under construction, for the purpose of adding to the tube-producing capacity of the country. The principal new plants are those of Spang, Chalfant & Company, of Pittsburg; of La Belle Vue Works, Steubenville; of the Lanesville Works, Ohio; of the Sharon Steel Company; and of the Youngstown Iron and Steel Company, Youngstown, Ohio. Other plants on a smaller scale are being constructed, so that probably it is not an excessive figure to compute the annual capacity of the whole of the tube works, built or building, at nearly two million tons a year. So far as I know, the actual output of tubes in the United States has never been recorded, but it is not at all likely to have much exceeded two-thirds of this figure.

E.—THE TINPLATE INDUSTRY.

Short Historical Review.

It was unfortunate that the tinplate manufacturers of South Wales did not, in accordance with their original intention—and solely because they did not look upon the date as propitious, on account of the strike in the American works—send two of their number as part of our Commission. This circumstance has imposed upon me, with a view to the completeness of this Report, the duty of saying something as to the tinplate industry of the United States, which they, had they accompanied us, would have said with much greater authority.

It is a matter of common knowledge that the tinplate industry is one of the most recent in the United States, and has been built up on the McKinley Tariff of 1890, which levied a duty of 2½ cents per lb. on all tinplate imported into the country, and practically caused the Customs to claim as much on imports into the United States as the price of the product at works in the Principality.

At the time the McKinley Tariff came into force, there was practically no tinplate manufactured in the United States, and the imports of that commodity ranged from 300,000 to 400,000 tons a year. In the following year, the home production was only 552 tons, and the imports of British tinplates were 327,882 tons. Since then the American production has increased year by year, while the American imports have as rapidly declined. In 1900, the total American output of tinplates exceeded 400,000 tons, and the imports had fallen to only 58,000 tons, or about a sixth part of what they were in 1890.

The following table shows the British exports, American imports, and American output of tinplate for the last 13 years :—

Year.	Exports from Great Britain to all countries. Tons.	Imports into U.S.A. Tons.	American Production. Tons.
1889	430,623	331,311	—
1890	421,797	329,435	—
1891	448,732	327,882	552
1892	395,580	268,472	18,803
1893	379,233	253,155	55,182
1894	354,081	215,068	74,260
1895	365,082	219,545	113,666
1896	266,955	119,171	160,362
1897	271,230	83,851	256,598
1898	250,953	67,222	326,915
1899	256,629	58,915	397,767
1900	273,954	60,386	302,665
1901	171,657	—	—

The imports of the past three or four years have been confined almost entirely to tinplates, which are re-exported in the shape of cans, containing oil, fruit, fish, etc. By the terms of the Dingley Law 99 per cent. of the duty originally placed on such tinplate is refunded by the Government on its re-export.

Sharon Tinplate Company's Works.

One of the most notable features of the recent course of the American tinplate industry has been the establishment of an extensive new plant at Sharon, Pa., by the Sharon Tinplate Company. This plant, originally intended to comprise only ten mills, has now been increased to twenty, the hot mill building being 900 ft. long by 108 ft. wide. The mills have varying widths of rolls, the least being 30, and the greatest 36 in. The complete plant embraces 22 sheet furnaces and 20 pair furnaces, all fired with producer-gas. Ten mills draw their power from a Buckeye condensing engine, and ten from a compound condensing engine—the first by the Buckeye Engine Company, of Salem, Ohio, and the second by Mackintosh, Hemphill & Company. In the cold mill, which is 520 ft. by 88 ft., there are six annealing furnaces, equipped with Swindell chargers. Of the 13 stands of cold rolls, 12 are driven tandem, the other being 24-in. one pass.

The block pickling room, which is 72 by 90 ft., is equipped with two Mesta pickling machines, supplied by the Mesta Machine Company, of Pittsburg. The tin house, 72 by 212 ft., is equipped with 24 sets of doubling machines. The process of making tin and terne plate is continuous. The power house is equipped with 250 h.p. Buckeye cross-compound engines, direct-connected to two Westinghouse generators.

Situation in Pennsylvania.

The works engaged in the manufacture of tinplates in the United States are mostly located in the State of Pennsylvania, but they are also to be found in nearly all the eastern and middle States, and the tendency appears to be to increase the area within which they operate. Little more than a year ago, the American Tinplate Company—one of the constituents of the American Steel Corporation—owned 282 tinplate mills, and 34 others were owned by independent concerns, while 30 others were reported to be in course of construction. Since then, however, there have been a number of new mills projected in different localities, the completion of which is likely to give to the American tinplate industry a capacity exceeding half a million tons a year.

The general tinplate situation in Pennsylvania is indicated by the following figures, extracted from the report for the year 1900 of Captain J. M. Clark, chief of the Pennsylvania State Bureau of Industrial Statistics :—

"In 1899 Pennsylvania had 21 blackplate plants, 18 under one ownership, five of which were subsequently dismantled, and the remaining 13 operated for a part of 1900. Two of the remaining three were operated in 1900, making 15 blackplate tin works plants operated in Pennsylvania in 1900. The average number of days of employment was only 201, owing to wage disputes. The capacity for 1899 was 1,017 net tons daily, and for 1900 1,014 net tons. The capital invested was 9,315,000 dols., as against 8,150,000 dols. in 1899. Production of blackplate for tinning was 302,928,000 lbs., 255,844,000 lbs. being tinned ; value of the tinned production, 10,561,760 dols. ; total value of the output of the blackplate works, 12,197,787 dols. There were 7,069 workmen employed, skilled

and unskilled, boys, women and girls. The aggregate wages paid was 3,428,259 dols.; average earnings, 484 dols. 97 cents; average daily wage, 2 dols. 41 cents.

Six tinplate dipping works were in operation, having 48 tinning sets, with a daily capacity of 194 net tons of tin and terne plate; capital invested, 451,827 dols. The aggregate wages paid was 137,700 dols.; average earnings, 371 dols. 8 cents; average daily wage, 1 dol. 47 cents. Total production of tin and terne plate by blackplate and dipping works, 289,392,000 lbs.; value, 12,669,747 dols.; average value per 100 lbs., 4 dols. 38 cents."

Tinplate Works and Engineering Firms.

The tinplate works under the control of the Steel Corporation were supposed to have a notable advantage over the independent plants in virtue of having an arrangement made with a number of leading firms engaged in the design and manufacture of machines of different types especially adapted for that industry. Nine of the leading machine-making and iron-founding firms in the country are stated to have agreed not to do any work for independent tinplate firms, so that competing plants were to be excluded from the advantage of having work done or designs prepared by such firms. It is, however, since stated that this arrangement has not been continued, whence it seems probable that the pressure of outside plants has proved too much even for the Steel Corporation.

The Star Tinplate Works.

I had the opportunity accorded me by Mr. Schwab to visit any, or practically all, of the tinplate works belonging to the United States Steel Corporation, which means the largest number of the best plants in the country. One of these was the Star Works of the American Tinplate Company, Pittsburg, over which I was shown by Mr. J. R. Phillips, the district manager, and Mr. A. E. Piper, the superintendent.

At the Star Tinplate Works in Pittsburg, during 1900, the output per mill per turn was 6,500 lbs., and there are eight mills in operation, so that the total output of tinplate is close on 20 tons per turn. Each mill is served by one roller, one heater and one doubler. The roller is paid 11 dols., the heater 6½ dols. and the doubler 7½ dols. per shift. Labourers are paid 1½ dols. The shift is one of ten hours for labourers and eight hours for the other hands. The girls who are employed as sorters are paid 1 dol. 15 cents per shift.

The engines that actuate the rollers are of the direct-connected Corliss type, with 42-in. cylinder by 60-in. stroke, working at 100 lbs. pressure. There are two such engines, each of them working four mills.

The standard size of plate made here is 14 by 20, but a number of other sizes are produced. The firm produces its own blackplate. The bars used are 8 and 10 in. by 30 ft. long. From the bar of this size to the finished plate there are usually twelve passes through rolls of 26 in. diameter and 32 in. long, with 20-in. necks. The mills are served by sixteen furnaces with two doors each.

At the time of my visit to the Star Works, they were only working partial time, owing to the strike which took place in the summer of 1901. The majority of the men employed previous to

that time had belonged to the unions and were of Welsh origin, among whom the sentiment of unionism was uncommonly strong. The owners did not greatly mind this, so long as it was not permitted to interfere with the liberty of non-unionists and the progress of the concern. After the strike, however, they made up their minds that in future they would get rid of the union, and hence, on the first day of September, they started as a non-union establishment, and they intimated that they knew of no reason why this condition should not be maintained. While there were still a number of Welshmen engaged, the native Americans, who were much less troublesome to deal with, would soon be in a majority.

In ordinary practice a 30-ft. bar is cut up by a shears into lengths that average 20 in. These short lengths are taken from the shears by a crane, loaded up into a rack under the crane, which swings them up into a stand between the mills, and the men then load by hand.

All the machines throughout the works are run by electric motors. One such machine runs the tin-house, and another runs the slitting shears. The rolls are turned every week, after they have put through about a thousand boxes.

Some weeks before my arrival at Pittsburg the Monessen system of connecting mills had been adopted at the Star Works, at one of the groups of mills, as well as at the company's Monongahela Works. By this change, they raised the output from 5,750 to 6,500 lbs. per mill per turn. As this system has been described in the *Iron and Coal Trades Review*, it is needless to speak of it here at greater length, but I was informed that its adoption involved no material alteration in the conditions of labour.

The annealing furnaces employed at the Star Works are specially suited to meet the requirements of natural gas fuel, which is here employed. The furnace is of circular form, and is built into the ground. It has an iron casing and a brick top, which is movable by crane. The furnace is 11 ft. diameter by 5 ft. deep. The charge put into the furnace is usually six or seven pots of 5,500 lbs. each. Two different annealings are generally given, the second one being cold. Altogether, there are nine annealing furnaces. I was informed that the only other furnaces built on this system are at Elwood, Indiana. These, however, are not new, having been here since 1895.

In cold rolling at the Star Works, conveying tables are used, placed between the different stands, and set tandem. By this arrangement the labour of catchers and rollers is saved.

Electric light is employed in the assorting room at each bench and table; it is also used in other departments of the works.

The pickling is done by three-armed picklers, with three crates—one of them in the swilling bath, one in the pickler, and one outside for loading and unloading. The vats are about 7 ft. long by 8 ft.

The use of natural gas fuel not only gives the works an unusually clean and tidy appearance, but it is a more economical fuel, and it obviates the employment of certain grades of labour, such as ashmen, who would be required with coal fuel.

When in full operation, the works employ 500 hands, and have a capacity of 350 gross tons per week.

General Survey of the Tinplate Industry of To-day.

At the end of 1901 there were in the United States fifty-five tinplate and terne plate works, with seven building and one projected. Of that number, forty-one were equipped for the manufacture of both tin and terne plates; ten, built or building, were equipped for the manufacture of tinplates only; and seven, built or building, were equipped to produce only terne plates. At the same date the Steel Corporation had twenty-five works completed and one being constructed.

The fifty-five tinplate works in the United States to-day are scattered throughout eleven different States and Territories, but chiefly in Pennsylvania, where there are twenty-four of them, and in Ohio, where there are twelve.

The largest tinplate works in the United States are those known as the American, at Elwood, Indiana, which possess 59 sets, and are equal to an output of 30,000 boxes per week of 112 plates, 14 in. by 20 in., full weight of 100 lbs. The Americans use the word set, and it is applied in these returns, to signify the set of tinning pots, or the machine used in tinning or coating the block plates. Only three of the works of the Steel Corporation have a weekly capacity exceeding 20,000 boxes. Two independent works produce 20,000 boxes weekly, or more, while six such works have ten sets or more.

The following is a statement of the principal tinplate works belonging to the Steel Corporation in the United States, and their capacities in tin and terne plates:—

Works.	No. of sets.	Weekly capacity, in boxes.
American, Elwood, Indiana	59	30,000
Newcastle, Pa.	32	16,000
Muskegon, Michigan	14	5,500
Pennsylvania, Pa.	10	5,000
Pittsburg, Pa.	12	5,000
Laughlin, Ohio	42	20,000
La Belle, W. Virginia	15	9,000
Beaver, Ohio	14	6,000
Demmler, McKeesport	14	7,000
Shenango, Newcastle, Pa.	36	24,000

The total capacity of the works belonging to the United States Steel Corporation is officially estimated, for 28 completed rolling mills, on triple turn, at 552,750 tons of black plates or sheets annually, to which a new mill in course of being built at the end of 1901, was estimated to add 12,000 tons. The capacity of the 25 completed tin and terne plate works owned by the corporation was at the same time computed at 220,900 boxes of 100 lbs. each on double turn, while new plants were computed to add 6,000 boxes to that figure.

The following are the names and the resources of the principal independent plants engaged in the manufacture of tin and terne plates:—

Works.	No. of sets.	Weekly capacity, in boxes.
American Tinplate Company, Pa.	10	1,440
Meurer Brothers, New York	8	1,800
Griffiths Company, Washington	8	4,500
Follansbee Brothers, Pittsburg	5	2,200
Lalance & Grosjean, Pa.	6	2,000
Merchant & Co., Pa.	8	4,000
Philadelphia Iron and Tinplate Company	6	2,300
Sharon Tinplate Works	24	20,400
Washington Tin Mills, Washington Co.	7	2,520
Waynesburg, Pa.	7	1,800
Baltimore Works, New York	16	10,000
Wheeling Corrugating Company	9	4,000
Maywood Works, New York	18	11,000
Chicago Tinplate and Can Company	20	7,300
Waukeshat, Wisconsin	24	20,000

It seems to be pretty certain from the available records that whatever "virtual monopoly" of the tinplate trade the Steel Corporation may have possessed when it was founded, or whatever the amount of control exercised over the trade at an earlier date by the American Tinplate Company, competitive concerns have since increased largely and rapidly, until the 26 tinplate works under the control of the Steel Corporation are less than one-half of the whole number. While, therefore, the action of that consolidation cannot be regarded as uninfluential in the affairs of the tinplate trade, it is not likely to be all-important, as it would have been while independent concerns were less numerous.

The number of completed tinplate works in the United States at the end of 1901 was 55, compared with 69 in April of 1898, and the same number at the end of 1895. Hence the number of existing works at the end of 1901 was less than that of either of the two previous periods. But the amount of enterprise being shown at the end of 1901 in adding to the productive capacity of American tinplate plants was greater than at either of those previous dates. Mr. Swank's figures show that at the end of 1901, no fewer than seven new tinplate works were in course of construction, against one in April, 1898, and four at the end of 1895. Of the new works being built at the end of 1901, three were in Pennsylvania, two in West Virginia, one in Ohio, and one in Wisconsin, while one other was at that time projected in Illinois. The aggregate capacity of the whole of the tinplate works of the United States is not quite known, but it is computed at over 700,000 tons, which is a good deal in excess of any actual output hitherto reached in the United Kingdom.

During my stay at Pittsburg I obtained a copy of *The Western Scale of Prices Governing Wages in Rolling Mills for the Year* 1901, as published by the "National Lodge of the Amalgamated Association of Iron, Steel, and Tinplate Workers." This little handbook of 38 pp. is really a guide to the wages paid in bar, 12-in., 10-in., guide, hoop, cotton-tie, puddle plate, tank, sheet, structural, and tinplate mills, as

also of the rates paid for boiling, bushelling, shingling, heating slabs, knobbling, working pipe from iron or steel, or other operations. The rates in question are fixed under an agreement known throughout the trade as the American scale, and subscribed by the representatives of both employers and employed. The agreement is founded on "the actual sales and shipment of iron and steel, as arranged for in conferences," and for such periods as may be agreed upon. It may be noted here that one of the provisions of the scale is that iron mills working steel are required to pay price and a half for steel, except mild steel, and another is that on all mills working iron or steel weighing 160 lbs. or over extra help is furnished to the heater at the expense of the firm.

The following are typical rates of wages paid under this agreement—in dollars and cents :—

	Description of Gauge.			
	8 to 11	18 to 20	29 and 30	40
Roller	1·81 ...	3·20 ...	4·34 ...	6·89
Doubler	1·07 ...	1·87 ...	2·91 ...	4·94
Heater	0·98 ...	1·70 ...	2·68 ...	4·83
Catcher	0·54 ...	0·96 ...	1·30 ...	2·06

The scale goes up to 44 gauge, for which rollers are paid 7·60 dols., and doublers 5 dols. 86 cents., the total number of gauge rates being twenty-three. The scale also provides for the payments to be made for shearing on jaw or crocodile shears and job or sheet work, from 1·26 dols. for 8 to 11 gauge to 1·55 dols. for 44 gauge; for shearing tinplate or squaring shears, from 41 cents up to 24 gauge to 79 cents for 44 gauge, and for a screw boy at 40 cents up to 24 gauge—all per ton.

The scale fixes the limit of a turn's work of eight hours, which varies as under :—

Gauge.	100 lbs.		Gauge.	100 lbs.
No. 8 to 12 ...	13,500	...	30 ...	5,750
„ 18 to 20 ...	9,500	...	33 ...	5,150
„ 25 ...	6,750	...	35 ...	4,950

Some of the regulations laid down under the scale are deserving of notice. One of them is that eight hours shall be a day's work on block or tinplate mills; that no more than three changes in the classification of tinplate mills can be made during the scale year; that the weight of the bar shall be marked on it when brought to the mill; that men working under the control of the amalgamated association shall not wait in the mill longer than three hours without working; and that all mills over 32 in. wide shall be classed as large mills, and 10 per cent. extra paid for all such widths. Another important rule, levelled at the contract system, is that certain classes of men "shall receive their money directly from the company."

The minimum and maximum base weights of each gauge are fixed at the following figures :—

Gauge.	Minimum.	Base weight per box.	Maximum.
30 ...	102 lbs., 2 oz. ...	108 lbs., 14 oz. ...	115 lbs., 11 oz.
31 ...	91 lbs., 14 oz. ...	95 lbs., 5 oz. ...	102 lbs., 1 oz.

F.—WIRE RODS, WIRE, AND WIRE NAILS.

Capacity of American Wire Works.

The importance of the wire industry of the United States is pretty clearly denoted by the fact that in 1899 the output of wire rods was not less than 1,036,398 tons, which, however, in the following year had fallen to 846,291 tons. When in Cleveland (Ohio) I called at the offices of the Garrett-Cromwell Engineering Company, and was supplied with a list of the Garrett wire rod mills in the United States, which showed a total capacity of over two million tons a year, so that the capacity of the plants now built is considerably in excess of any annual output yet recorded. The wire rods are, of course, worked up into a variety of finished products, but one of the most statistically striking is that of wire nails, of which in 1899—the banner year—the total output was not less than 7,618,000 kegs of 100 lbs. each, or 340,090 tons. This extraordinary make of wire nails has compelled the United States to seek for foreign markets for a surplus that they appear quite unable to dispose of at home. The largest export hitherto recorded under this head was 33,517 tons in 1899. In the same year, 16,992 tons of wire rods were exported, so that the home consumption of wire rods in that year must have been more than a million tons.

This vast capacity is being materially increased at the present time. The Garrett-Cromwell Engineering Company informed me that they had under construction at Pueblo, for the Colorado Fuel and Iron Company, one mill of 600 tons capacity per 24 hours; another mill of 400 tons capacity for the Pittsburg Steel Company, within 40 miles of that city; and a third mill of 200 tons capacity for a firm in Indiana. Hence, the new works in hand by this one firm represent an increased capacity in wire rods of 1,200 tons per day. Moreover, the Garrett-Cromwell Company had just put into operation at Pittsburg a new rod mill of 300 tons daily capacity for the Union Steel Company, and I was told that it is proposed to double this capacity in 1902 if trade keeps good, while a smaller mill, of 150 tons daily capacity, had practically been arranged for the Page Woven Fence Company, an enterprise carried on within 50 miles of Pittsburg.

This enormous advance in the resources of the country for the production of wire and wire products would seem to a large extent to be justified by the recent progress made in the demand for those products. That progress has never before been so strikingly shown as in the year 1901, when the total output of wire rods rose by the extraordinary figure of 519,643 tons, or fully 61 per cent. over that of the previous year. It is true that the increase of 1901 over 1899 was materially less than this figure, having been 329,000 tons, or 31 per cent., but even so the advance has been unique in the history of the wire industry of the United States, and, it need hardly be added, of all other countries. Since 1895, the increase in the output of wire rails has been about 70 per cent.

Among recently erected rod mills of importance, mention may be made of that built at Ensley, Alabama, of which I shall have more to say presently, with a capacity of about 300 tons; that built at Ashland, Kentucky, with a capacity of about 300 tons; and that built

for the Sharon Steel Company (whose works are elsewhere referred to*), started a few months ago, with a capacity of about 400 tons per day.

The bulk of the wire-rod mills in the United States to-day are owned by the American Steel and Wire Company, which has 13 different wire-rod plants, 23 wire-drawing plants, and 16 wire-nail plants under its control, representing an annual capacity of 1,250,000 tons of wire rods, 1,562,000 tons of wire, and more than 12 million kegs (100 lbs. each) of wire nails. It will be noted that this one enterprise controls an annual output of all three greatly in excess of any output secured in twelve months up to the present time.

Nevertheless, it was announced some months ago, and is regarded in well-informed quarters as not improbable, that the new plants recently constructed, under construction, or projected, would be equal to an output that would not come far short of adding 50 per cent. to these figures. However this may be, it seems to be clear that the capacity is already largely in excess of the demand, that it is certain to be more so in the future, that there is likely to be a very keen competition for business between the Steel Corporation (of which the American Steel and Wire Company is a constituent concern) and independent manufacturers, and that the plants available can only be expected to keep going by invading foreign markets more largely than has hitherto been done.

The Present Statistical Position of the Wire Industry.

At the end of 1901, the total number of iron and steel wire rod mills in the United States was 32, with four building, one rebuilding and one projected, making 38 in all. The chief works were as under:—

	Tons.
National Wire Corporation, New Haven	90,000
Rankin Works, Pa.	100,000
Hartman Manufacturing Company, Pa.	275,000
Monessen Works, Pittsburg	130,000
Sharon Works, Pa.	125,000
Union Steel Company, Pa.	200,000
Southside Works, Pittsburg	90,000
Beaver Falls Works, Pa.	100,000
Allentown Works, Pa.	75,000
Braddock Works, Pittsburg	80,000
Newcastle Works, Pa.	90,000
American Iron and Steel Works, Pittsburg	100,000
Ashland Company's Works, Ky.	100,000
Alabama Wire Company's Works, Ala.	100,000
American Steel and Wire Company (four works)	405,000
Joliet Works, Chicago	260,000
Waukegan Works, Chicago	100,000
Anderson and Kokomo Works, Indiana	150,000
Griswold Wire Company, Illinois	50,000
Grand Crossing Company, Illinois	45,000
National Wire Corporation, New Haven	90,000
New York and New Jersey Companies	145,000
Smaller Companies...	75,000

The principal representative of the wire industry of the United States is the American Steel and Wire Company, one of the constituents

* See Report by Mr. Enoch James, p. 540.

of the United States Steel Corporation, which has 11 blast furnaces, 15 rolling mills and steel works, 13 wire-rod plants, 23 wire-drawing plants, and 16 wire-nail plants.

The capacity of the various plants of the company is given in the *Directory of the Iron and Steel Works of the United States* at the following figures :—

	Tons.		Tons.
Pig-iron	1,030,500	Wire rods, etc. ...	1,755,000
Bessemer ingots ...	935,000	Wire	1,562,500
Open-hearth ingots	365,000	Wire nails... ...	12,385,000 kegs.
Billets, slabs, etc....	890,000		

The rapid progress of the wire industry is indicated by the fact that in 1875 the output in the United States was only 250,000 tons, but this figure had in 1898 increased to 1,200,000, and this year it is expected to considerably exceed a million and a half tons.

I have analysed the wire-rod manufacturing plants of the United States, at the end of 1901, with their annual capacity as given in Mr. Swank's *Directory*, and find their total capabilities to be 2,970,000 tons a year. The capacity of the 13 wire-rod plants belonging to the United States Steel Corporation is given by the same authority at the same date as 1,250,000 tons a year. Hence the capacity controlled by the United States Steel Corporation appears to be about 42 per cent. of the whole of the country.

The Ensley Wire Works.

At Birmingham (Ala.), I had the opportunity of seeing over the works of the Alabama Steel and Wire Company, which is one of the latest wire works hitherto constructed in the United States. This company buys billets measuring 4 in. by 4 in. from the Tennessee Coal and Iron Company. The works have a capacity of some 100,000 tons per annum, of No. 8 rods, from 1,000 to 1,200 ft. long. The chief finished products are fencing wire and wire nails. The billets produced by this company run from ·14 to ·17 carbon, ·03 to ·05 sulphur, and ·04 to ·06 phosphorus. A noticeable feature of the plant is the adoption of hot metal from the adjoining steel plant of the Tennessee Coal and Iron Company. At the time of my visit the company were being paid 28 dols. per ton for fencing wire, but they were not so fully employed as they would have been had not the region south and west of the Mississippi, to which they mostly limit their business, had a short crop.

The plant at these works is of the latest type in nearly all its details. The rod mill, of the latest Garrett type, cost the firm 350,000 dols. There are 18 passes through the rolls from the 4-in. billet to the No. 5 gauge size of rod, which is accomplished in a minute and a half. We saw two or three rods being put through at the same time.

For the manufacture of nails the company employ 171 so-called Kilby machines, which, however, they have modified to their own requirements. Each man attends to from 10 to 14 nail machines, with a couple of helpers who feed in the wire and take care of the machines. The latter are paid 25 cents per hour. The works can produce 4,000 kegs (100 lbs.) in 24 hours, up to 12-in. spikes.

In the wire-drawing department, there are 217 blocks, arranged in a building which is 360 ft. long. The blockmen have each two blocks to look after, and each block produces two tons in the 24 hours. Generally these men, who are paid by piece, make about 7 dols. a day.

The barbed wire machines, of which there are a number, average about 2½ tons of finished product per day.

Several galvanizing furnaces are used, instead of passing the wire through molten lead, which is regarded as too expensive and unnecessary. About 75 tons per furnace per day is regarded as an average output.

The labour conditions at these works are somewhat exceptional. For ordinary unskilled labour, negroes are mainly employed. Over one-half of the wire-drawers were also negroes. Boss rollers are paid about 5,000 dols. per annum, and second rollers 3,000 dols. Excepting these, there are none on the works paid more than 2,000 dols. a year. A dollar a day is the standard wage for unskilled labour, and until a year and a half previous, it was only 90 cents. The total number of hands employed ranges from 900 to 1,300, according to the work in hand.

The Wire-Rod Mills at Sharon.

The rod mills of the Sharon Company are of the Morgan continuous type, and are driven by two pairs of 32½ by 60 by 60 in. engines, with 82-in. rope wheel, worked by a 16-ft. pulley which drives part of the mill. The other part is driven by a 4-ft. wide belt on the same shaft. The rod mill contains six stands of 10-in. roughing rolls, and a finishing train of eight stands of 10-in. rolls, an Edwards flying shear being interposed between the two for cropping the split ends. The rods are afterwards taken to two sets of four-rod reels of the Morgan-Stevenson flying-pipe pattern, with inclined laying platform and travelling coil conveyor. The latter delivers the coils to the pickling house. After leaving the pickling house the rods are taken to the annealing furnace building, and after being annealed are either shipped to the open market or taken to the wire mill. The pickling house is equipped with two pickling cranes and one baker. A galvanizing department is also located at one end of the pickling house, the equipment consisting of two annealing furnaces, necessary water and acid tanks, two spelter frames, and two take up frames for 20 wires each. The annealing house contains one set of annealing pots and one set of cooling pots, and is commanded by two revolving steam cranes.

The wire mill is 780 ft. long with a 70-ft. span, and there is room for 150 wire benches. This building also contains the galvanizing department, which is located at one end of it. In the wire mill is an overhead trolley.

In the Sharon billet mill, the billets, after reaching the proper degree of heat, are dropped upon a conveyor, which carries them to the mill to be rolled. The billet mill has three pairs of rolls of 16 in. diameter, and three pairs of 13 in. diameter, and is driven by a pair of 28½ by 56 by 62 compound steam engines. The billets are rolled 1¾ in. or larger.

Mr. William Garrett, the inventor of the Garrett rod mill, which has done so much to increase the output of wire rods in the United States, has stated in a recent article contributed to the *Iron and Coal Trades Review* (April 11th, 1902), that of the total production of wire rods in the year 1901, he computes that not less than 80 per cent. were rolled as small as No. 5, while the balance was at least half a size larger, but still called No. 5. These rods were used for nails, barbed fencing, galvanized wire, weaving wire. Many thousands of rods were drawn from 5 in. by 7 in. to No. 20, without being annealed.

G.—THE AMERICAN CRUCIBLE STEEL INDUSTRY.

Historical Retrospect.

The crucible steel industry of the United States has had an interesting history. Up to about the year 1866, there was a common impression in the American trade that good crucible steel could not be produced in that country. Evidence on this subject was given before a Committee of Congress, which is rather amusing reading at the present time. Several enterprising Americans entertained a different opinion, and among them the late James Park, whom I had the pleasure of knowing intimately, and whose son now controls the large works and plants of the American Crucible Steel Corporation. These pioneers engaged men in Sheffield at high wages to go to Pennsylvania and help in the start of the trade, which, protected by high duties, was in a few years placed on a stable and prosperous footing.

Even up to the present time, however, the Americans import considerable quantities of crucible steel from England, and I was informed by several authorities that there is still in some quarters an idea that only England can produce tool steel of the highest class. The increasing strenuousness of those who are engaged in this business on the American side has induced several Sheffield firms to establish works in the United States rather than run the risk of entirely losing their American connection, and prominent among such firms may be named Messrs. Firth & Sons and Messrs. Jessop. While in Pittsburg, I met Mr. Lewis J. Firth, of Sheffield, who informed me that his firm had established large works in the neighbourhood of that city, employing over 600 men, who produce among their specialities projectiles and other munitions of war.

The total annual production of American crucible cast steel over the last 10 years has been about 100,000 tons. This is probably not greatly different from the British output of the same description of material, but there are no available records of the latter.

Some of the principal crucible steel works of the United States are those of Park Brothers, the Crescent Steel Company of Pittsburg, and the Midvale Steel Company of Philadelphia. Mr. Park refused my request to see over the works of his firm, a fact which I name chiefly because it was the only refusal I met with in the course of my inquiries. Among other leading companies engaged in this industry, the Midvale Company most kindly gave me access to their

important works, and readily answered all questions put relative thereto.

The Crescent Steel Works.

Before proceeding to deal with Midvale, I will put on record some data relative to the works of the Crescent Steel Company. These works extend to about 9½ acres of ground in the City of Pittsburg, one side extending along the Allegheny River and the other skirting the lines of the Pennsylvania Railway. The company employs both the crucible and the open-hearth systems of manufacture, the former plant consisting of the necessary converting furnaces and five melting furnaces of the regenerative type, which have a daily capacity of 50 tons. One of these is a 60-pot furnace, and it is claimed that this is the largest crucible furnace in operation anywhere. The company employ Swedish bar iron for the finest qualities of crucible steel, and their rolling mill plant consists of 11 mills in which are rolled sheets, bands, rods, wire, coil-springs, and other productions. The largest is a 14-inch mill, and there are two sheet and one cold-rolling mills.

The structural features of the works include a large machine shop, driven entirely by electrical power, and an ironfoundry in which the company make their own iron for the converting furnaces and crucibles. Those who were privileged to visit the Paris Exhibition of 1900 must have been struck with the fine display made by the company, which is one of the most enterprising and aggressive in the States. In that exhibit the company showed upwards of 600 finished articles, comprising 100 different kinds of tools and appliances, shown collaterally with the products, which had been contributed by about 120 American steel consumers.

The Midvale Steel Works.

Another of the most important crucible steel works in the United States, to which I was introduced by my old friend, Mr. R. Davenport, formerly general manager of the Bethlehem Steel Company, were those of the Midvale Company, situated at Nicetown, a few miles outside of Philadelphia. This is in some respects one of the most important works in the country, and it is probably wholly so in reference to the large number of specialities which it produces. Both the crucible and the open-hearth processes of manufacture are carried on, including acid and basic open-hearth, in these plants. The principal products of the company are steel forgings and castings, tyres, axles, projectiles, and shafting. The crucible steel manufactured runs the British product hard in the American market, as does that of the Crescent Company already referred to. The works extend over 53 acres of land within the municipal limits of the Quaker City, and I was informed that the land is worth 15,000 dols. an acre, which would make the site worth not less than 795,000 dols. The Midvale Company claims to have made the first steel tyres produced in the United States, about the year 1867, as well as the first open-hearth steel, and the first high-power and built-up steel guns.

The two principal departments of the Midvale Works are the steel foundry and the machine shop. In the former, which employs 300

hands, there are three open-hearth furnaces, served by electric cranes, and producing steel as required in large and small ingots, suited to different purposes. The Midvale Company have done much to extend the use of castings to purposes that were formerly served by forgings, such as gun mounts, parts of machinery, locomotive wheel centres, etc. Moulding machines are employed to a considerable extent, as well as the sand blast for cleaning the castings, and pneumatic chippers. Castings up to 40 and 50 tons have been made in the foundry, including some of the largest parts required for the large press of the Carnegie Steel Company. Basic steel, of which the output is limited to one small furnace, against seven acid open-hearth furnaces, is used for the manufacture of castings for electrical work, in which low manganese and silicon are required.

Of crucible steel, the Midvale Company manufacture eight principal grades, four under the head of "Midvale Regular," two under the head of "Midvale Special," and two under that of "Midvale Extra." These are all catalogued and issued to users, according to the different uses to which it is found in practice they are best suited. The company issue to all their users directions for forging and working different steels. They also produce a so-called self-hardening steel, for which they claim that "it is easily forged, and that more elaborate shapes can be made from it than from any other self-hardening steel on the market." One would like to hear what the established Sheffield steel manufacturers have to say on this claim.

In the crucible steel practice of Midvale, as of the United States generally, 2,000 lbs. per day is considered a fair output per hole in a single shift of 12 hours. There is little to distinguish American from British crucible steel making, if we except the fact that in the United States anthracite coal or natural gas are largely used as fuels in the place of coke, the usual fuel employed in English works.

The Midvale Company have applied basic steel to the production of both castings and forgings, but I was informed that it had been discontinued for forgings because it did not answer the needful requirements. The explanation given of this fact by the manager was the slag that is held in suspension in the steel. For ordinary structural purposes, basic steel is found satisfactory. Built-up crank shafts are supplied when ordered, and a department is assigned to their production.

For the tempering of both castings and forgings, the Midvale Company have two of the largest plants in the United States—the one equipped with a tank 100 ft. in depth, in which guns of the largest size, shafts of all dimensions, and other heavy forgings are annealed; and the other a tank 60 ft. deep for shorter and smaller objects. There are two smaller tanks for yet smaller productions. I was informed by the manager that the filling with oil of the largest tank involved an expenditure of 40,000 dols.

The forge at Midvale embraces a large rolling mill, with a 12-in. train; three tyre mills, where tyres of different sizes are rolled; one roughing and one finishing mill for general work, and two iron-rolling mills.

The projectile department, which is one of the largest, is fitted up with the necessary plant to enable the well-known Holtzer process, as carried on at Unieux, in France, to be applied. This process has been in operation here for upwards of 10 years.* Nickel steel, produced at the works, is largely employed for shafting.

In the gun department, the company make up to 13-inch guns, which is the largest size used in the Navy of the United States, excepting an experimental 16-in. gun. The company also make 6-in. armour.

The Midvale machine shops, like those at Bethlehem, which I also had the opportunity of examining, are of large extent, and produce an infinite variety of work in good style. There are altogether four machine shops, including two of large dimensions, which were being built, and almost ready for being roofed in at the time of my visit. What is known as No. 1 shop is devoted to the rough machining and turning of tyres, axles, etc., while No. 2 is devoted to the more complete finishing of these and other descriptions of work, including gun carriages. One of the new shops will be devoted to the building of marine engines, etc. The principal shop is commanded by three electric cranes at different levels, and is altogether a very fine structure, while it is hardly necessary to add that in this, as in all the machine shops of the company, the equipment is fully up to date, some of the machine tools supplied by Philadelphia being unique of their kind. A feature of the plant is the large use of pneumatic drills, worked with an air pressure of 50 to 60 lbs.

The Midvale Company, I was told, run every machine they have for all it is worth. The company do not recognise trade unions, and have no trouble with unionists. In giving out work to the different shops, they make use of books in which the speeds and the feed of each machine are set out, assigning the speed at which each piece of work, according to its diameter, is to be machined. Each expert workman is provided with a helper, who replaces tools, etc., and is expected to do a large part of the heavier work. Some of the forms used at Midvale in giving out work are printed in the Appendix. It will be noted that in the forms issued for the machine shop the workman has only the rough dimensions for a guide. On these being ascertained, the estimating department gives the workman both a high rate and a low rate, and he is paid according to the manner and time in which he gets out his work. Eight men of long experience are engaged in fixing up these rates, and all estimates are centralised, as far as possible. The work is largely done on the piece system, and premiums are given for specially good results.

The Midvale Company appear to possess an exceptionally industrious, sober, and capable body of workmen, which is, no doubt, mainly the result of their being located in a city where industry, intelligence, and sobriety are common characteristics, and to which workmen are generally attached by the circumstances of its being what is known as "a city of homes." Most of the responsible work-,

* The Unieux process is described in the *Journal of the Iron and Steel Institute* for 1889.

men possess their own houses, and live in unusual comfort, the rate of wages generally paid enabling this to be done. The hours of work, as at most of the other establishments in Philadelphia, are from 6.30 a.m. to 12, and from 12.30 to 5.10. Some of the shops, however, are worked regularly both day and night. The general rules affecting labour at Midvale are published in the Appendix.

The care which is taken of workmen at Midvale is perhaps somewhat exceptional, but not, on the whole, greater than I have found at some other establishments. In the first place, the company attach importance to a good education, and hence I found that every man in a really responsible position was a college graduate. Those apprentices who have not had the advantage of a good education are encouraged to identify themselves with the Franklin Institute, where, for a sum of 5 dols., they can have two lessons per week regularly in drawing, etc., for a term of 15 weeks, the company paying the fees.

In order to encourage men to remain in their service and to earn the reputation of being steady and capable, the company provide pensions or retiring allowances to men who are no longer fit for work, varying according to the length of service, and on a liberal scale, the highest rate of wages received during the term of actual service being taken as the basis of the pension. There are now 35 to 40 men in this category.

In the Appendix will be found the principal rules of the Midvale Beneficial Association, which will serve to convey an idea of perhaps the best form of organisation of its kind to be found in the United States. It will be noted that this scheme practically provides for sickness, accident, incapacity, and any other necessity of the workmen, on what, relatively to the wages paid, do not appear to be onerous terms.

The managing director of the Midvale Works is Mr. C. J. Harrah, the manager Mr. A. Petre, and the assistant-manager Mr. H. D. Booth.

In Pittsburg I learned that a great development is shortly about to take place in the manufacture of tool steel, when the works of the Colonial Steel Company at Monessen are completed, in the early months of 1902. This company is to devote itself mainly to high-grade tool steel; and an idea of its importance may be formed by the fact that the main building is 700 ft. long by 150 ft. wide, while the works have an area of about 40 acres.

General Situation of the Crucible Steel Industry.

The crucible steel industry is still one of considerable extent, although, of course, of less relative importance than formerly. At the end of 1901, according to Mr. Swank, there were 45 works in the United States producing this description of steel, with a total capacity of 175,000 tons a year, and employing 2,896 steel-melting pots, against 2,952 pots in 1898. The industry is therefore declining in importance.

The principal works engaged in this industry are those of Park

Brothers—the Black Diamond,—with 498 pots; the Crescent Works, with 180 pots; the Aliquippa Works, with 108 pots; Howe, Brown & Company, with 204 pots; the works of Sanderson Brothers, with 144 pots; La Belle Steel Works, with 120 pots; the Pittsburg Steel Works, with 66 pots; and the works of Singer, Nimick & Company, with an annual capacity of 13,200 tons of ingots. All these works are constituents of the Crucible Steel Company of America.

Besides these, however, there are a number of important independent concerns, including the Pittsburg Steel Works, with 66 pots; the Cyclops Works, with 36 pots; the Firth-Sterling Works, with 60 pots; the Jupiter Steel Works, with 72 pots; the Keystone Works, with 102 pots; Kidd Brothers, of Aliquippa, with 60 pots; the Carpenter Steel Company, with 120 pots; and the Braeburn Steel Company, with 60 pots; mostly in the neighbourhood of Pittsburg. The plant of the Midvale Steel Company, near Philadelphia, which is also extensive, is not recorded. While these works are all in Pennsylvania, there are other independent crucible steel works in New York, Connecticut, Massachusetts, New Jersey, Ohio, Illinois, Wisconsin, and Indiana.

Outside of the State of Pennsylvania, the principal strength of the Crucible Steel Company of America appears to be in New Jersey, where they control the works of the Atha Steel Company, 126 pots, and those of the Bergen Steel Works, 144 pots. Even in New Jersey, however, there are several independent works, with 50 to 70 pots each, and in New York there are the Chrome Steel Works at Brooklyn, with 54 pots.

On the whole, it may be said that while the Crucible Steel Company of America controls a large proportion of the bigger works, there is still a considerable independent residuum, which is being increased by new plants.

The steel-melting furnaces employed in American practice do not differ much from those made use of in Great Britain. Their usual dimensions are suited to take 24, 30, and 42 pots each. In some rather exceptional cases there are 60-pot furnaces, and the Park Steel Company have seven to contain 48 pots each. At the Park Company's works there are altogether 12 steel-melting furnaces for 498 pots. Sanderson Brothers, for 144 pots, have four 24- and four 12-pot melting-furnaces.

I learned that there is still in some quarters a considerable demand for British tool steel of the highest grades, and most of the leading Sheffield firms are represented by agents in the United States. As is well known, also, several Sheffield firms have lately founded works in the United States.

* *Directory of the Iron and Steel Works of the United States*, p. 15.

H.—THE MANUFACTURE OF FORGINGS AND WAR MATERIAL.

General Remarks.

It goes without saying that in a country that possesses so vast a mechanical industry as the United States, the manufacture of forgings is a business of immense importance. There are very few pieces of machinery for which forgings are not required. They also enter into the production of war material of different kinds, including armour plates, guns, and projectiles. The extent of the use of steel forgings for shipbuilding purposes is in Great Britain much more considerable than in the United States, although in the latter country, the recent important additions made to the navy have created an increased demand for forgings, and increased attention to their production.

There is, however, no record of the extent to which the manufacture of steel forgings is carried on in the United States. Nor is there any available record of the international movement in this branch of manufacture. The American Iron and Steel Association do not publish statistics of the former, nor do the Government of the United States publish returns of the latter. Of war material, however—and especially armour plates—the information as to output is much more complete; sufficiently so to enable us to know that the capacity of the two works engaged in this branch of industry is relatively small.

The principal tools employed in the manufacture of forgings continue to be the steam hammer and the forging press. In respect of these tools, I have no reason to believe that the United States are in any particulars of real concern ahead of our own country. It is true that nothing in Great Britain, nor, indeed, in the world, could equal the size and power of the steam hammer erected at Bethlehem Works in 1893, but many authorities are now disposed to look upon the steam hammer as an effete appliance, and to attach much more importance to the hydraulic press. There are two presses of great power in the United States—the one at the Homestead Works of the Carnegie Steel Company, which claims to exert a pressure of 16,000 tons, and a similarly powerful press is in operation at the Bethlehem Works—these being the only two works in the United States at which armour plates are produced; but I have been informed by a representative of the Whitworth firm in Manchester—and that firm was responsible for both the American presses—that the largest hydraulic press hitherto constructed is to be found at the Manchester works of the Armstrong-Whitworth Company, and that it is certainly a good deal more powerful than those of either the Carnegie Steel or the Bethlehem Iron Companies in the United States.

Apart from the forging of war material, steel has been largely used in the forging of pieces for electric and other engineering plant, and many works have provided more or less special plant for that purpose. Speaking generally, however, I cannot say that I came

across anything in this branch of the steel industry that struck me as "giving points" to our own manufacturers, if I except an incidental improvement in the material employed for producing tool steel, by what is known as the Taylor-White process, as practised at the works of the Bethlehem Steel Company.* So much has been said of this process in the technical Press that I need not describe it here. I was, however, informed that a similar process is practised at the Midvale Steel Works, elsewhere described, where forgings are produced on a large scale.

The Bethlehem Steel Works.

The works of Bethlehem were the first to which my colleagues and myself were favoured with a special invitation, and they were also the first that we visited in a collective capacity. We spent a whole day going over this well-known and notable establishment, which was founded in 1860, started iron mills in 1863, established Bessemer plant in 1873, when it was the chief rail-producing plant in the United States, added an open-hearth plant in 1888, introduced the Whitworth system of fluid compression some years later, produced the first armour plates rolled in the United States under modern conditions, about 1890, and has for a number of years past specially devoted itself to producing steel forgings, more especially in the form of guns, projectiles, crank shafts, and otherwise.

The Bethlehem Works are situated in the Lehigh Valley, nearly 100 miles from New York, and were originally founded with a view to the making of pig-iron from the ores of Pennsylvania, New York, and New Jersey, but for many years past they have chiefly smelted foreign ores, imported from Cuba, Spain, or other countries.

The general features of the plants do not appear to call for remark for the bulk of the work produced, especially as they are not at all likely to compete with Great Britain, although they have competed in Russia for armour plates under conditions that were a good deal talked about at the time.

Some years ago, the Bethlehem Company erected a magnificent plate mill, with the idea of going largely into the manufacture of plates, but the competition of rival concerns at home, and the belief that more special products pay better, led them to sell the plate mill to the Carnegie Steel Company, and it now forms part of the equipment of the Homestead Works, near Pittsburg.†

The Bonus Labour System.

Since the Bethlehem Works do not now profess to produce any of the ordinary descriptions of competitive merchant steel—rails, plates, etc.,—our attention had to be limited to their specialities as a steel-founding and engineering concern, which is practically the position they now occupy. But we were also much interested in the system under which the Bethlehem Works are carried on from the labour point of view.

* I am informed that Messrs. Vickers, Sons & Maxim have acquired the control of this process in Great Britain.

† See section on Steel Plates, page 134.

As to the earnings of the men employed in the machine shops at Bethlehem, the manager said: "We have the bonus system in operation here, and find it answers very well. Indeed, about 20 per cent. of our men draw bonus money. Common labour is paid 1·25 dols., and the average of all in the machine shop is 2·60 dols. per day, which has gone up recently from an average of 2·25 dols. Taking the mechanics throughout the country generally, a rough average of to-day would be 2·60 dols. per day, against 2·40 to 2·50 a year ago. At Bethlehem, the men in the machine shop will earn from 40 to 55 cents

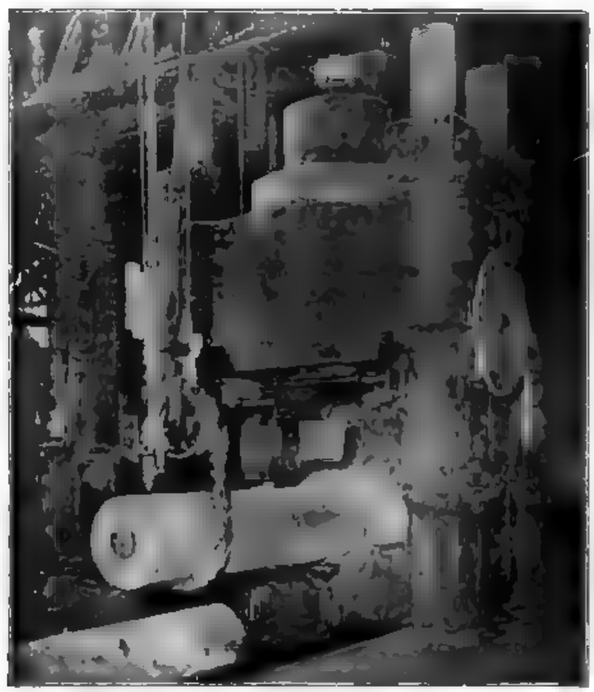


FIG. 41.—FORGING A STEEL SHAFT AT BETHLEHEM WORKS.

per day more than their regular wages, and the foreman will average 10 to 20 cents more, because of the bonus system. We pay our workmen by the day, but set a measure of work for each, which is determined by experienced men on the basis of what has been done before. Thus in shop work, if we set, say, four holes for a man to drill in a given time, and he does five holes, he has a bonus on 2½ hours. The shops are divided into groups of tools. The same bonus system is applied at the machine shops of Bement, Miles & Company and W. Sellers & Company, of Philadelphia, and at the Baldwin Locomotive Works. The basis of the system is to pay the workman one-half of the value of the work he does in excess of the measure set him. This is an excellent way of determining the efficiency of the workmen. Many men do not earn any bonus, and of course they are

not regarded as being such good workmen as those who do. If a man complains that the task set him is too much, we put on another man to show that it can easily be done.

The Taylor-White Process.

"Since we adopted the Taylor-White process all our tools have been considerably speeded up, as that system enables much larger shavings to be taken from the forgings or other work in hand, and thus makes a larger daily output possible, without the tools suffering from the heat. The increase of speed is generally 2 or 2½ to 1, but of course in the time occupied in changing tools, etc., there is no economy."

At Bethlehem, the text, "By their deeds ye shall know them," appears to be rendered "By their chips ye shall know them," for the foremen judge the skill and capacity of a workman by the size of his chips. In using tools manufactured of Taylor-White steel, the chips should be entirely different to the ordinary chips known in English practice, and if they are not sufficiently blue in colour, the inference is that the man is not working his tool at a sufficiently high speed. No limit is placed upon the number of tools a man may have. He gets all the tools he wants, and they are all ground for him, so that no time is lost in this operation. The tools, it may be added, are ground in two special machines, by emery and carborundum.

Standardisation of Tools.

The tools at Bethlehem are all standardised, as to shape, clearance, etc. Many experiments are made from time to time to determine what the tools will stand. The life of a tool, of course, mainly depends on the composition of the steel, and this and other considerations are always allowed for in the rate of speed fixed. As the manager remarked to me, "We don't expect a workman to do as much work on nickel steel as on steel of ordinary composition." I visited the tool-room attached to the Bethlehem shops, where I saw over 6,000 tools in stock, all classified and sorted according to their uses, etc.

The Bethlehem Company chiefly manufacture guns, armour, and large forgings generally. They have constructed 4-in., 6-in., 10-in., 12-in., 15-in., 16-in. and 18-in. steel guns, and they were the first in the United States to manufacture armour plates, for which they then provided a 120-ton steam hammer, a model of which was one of the *tours de force* at the Chicago Exhibition of 1893, and afterwards a hydraulic press of 14,000 tons capacity on the Whitworth system, which is still claimed as the most powerful in the world.

The company at the time of our visit, were producing a hollow steel forged crank shaft, with nine eccentrics and 13 different centres, all in one solid piece, which is a fair example of their skill in exceptionally difficult work.

The Engineering Shops.

One of the most striking of many striking things that came under my notice in visiting American works was the engineering shop of the Bethlehem Steel Company, which is about a quarter of a mile

in length, or, exactly, 1,550 ft. by 120 ft. in three aisles, the centre one being of 60 ft. span. This shop is altogether phenomenal—alike in its size, its equipment, its methods, and the work on hand. Its equipment embraces some of the largest and finest tools in the world, including a planer 52 ft. long by 13 ft. 4 in. wide (which is the largest I remember to have seen), and worked at a speed of 18 to 19 ft. per minute; a boring machine, 14 ft. wide, between columns, and 19 ft. high, of the Bement & Miles type, and capable of boring at any angle; a special tool for cutting up ingots, with four cutting tools, and three rests on each side; and others almost equally noticeable. As regards methods, I may take leave to doubt whether in any shop of its kind, the tools generally are so high speeded as here, and, indeed,

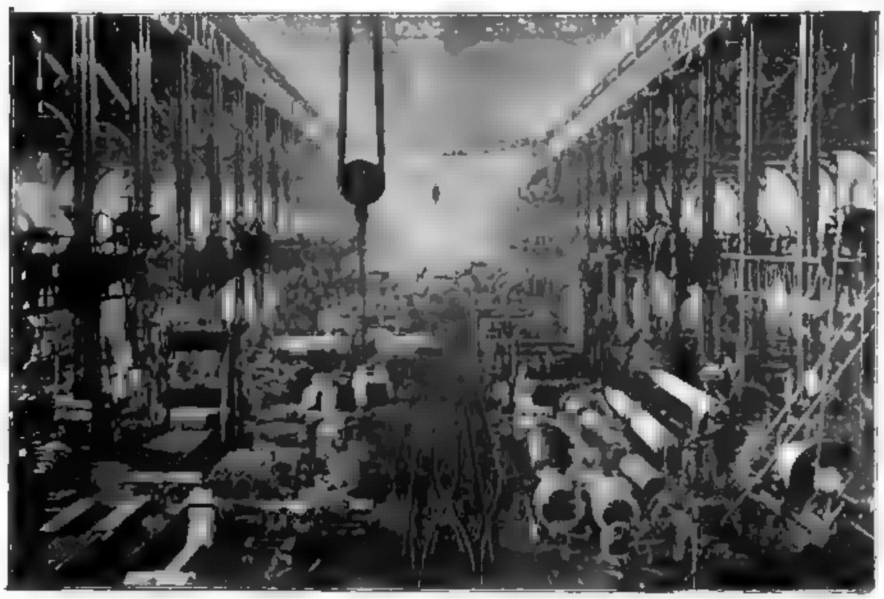


FIG. 42.—INTERIOR OF THE GREAT ENGINEERING SHOP AT BETHLEHEM—A QUARTER OF A MILE LONG.

most of the lathes have lately had to be re-designed in order to provide for the higher speeds that have followed upon the introduction of the Taylor-White process. It is the practice here for certain purposes to trepan out the ingots with a bore at both ends by hydraulic pressure, and we saw such holes being bored up to 16½ in. diameter, for a gun tube. Trunnion bands are forged hollow, the trunnion being drawn out of the ingot. Shafts are bored at the rate of 7 in. per hour, for a 6-in. hole, the boring being done at the same rate at each end. The newest mill provided for this class of work is electrically driven and has cut gears throughout. Shafts are in some cases bored at the rate of 10 ft. per day, the speed varying with the composition of the steel. Some tools were seen turning up complicated cranks with all the eccentrics on. The remarks that have been made as to the speed of

work generally apply equally to the drilling and planing of armour plates, of which we saw several 11 ft. by 14 ft., and weighing 33 tons, under treatment.

The Bethlehem Steel Plant.

The steel-producing plant at Bethlehem is of a more or less special character, and adapted to more or less exceptional work, such as the manufacture of armour, projectiles, and large forgings. There are altogether in the steel-melting department eight open-hearth furnaces

FIG. 43. STEEL INGOT AT BETHLEHEM, ABOUT TO BE FORGED.

of 10 to 40 tons capacity, some acid and some basic. They are served by overhead electric cranes, and an electric Wellman charging machine. The largest ingot hitherto produced has been one of 66 in. diameter, and 58 tons. The steel produced is mainly adapted to meet the navy requirements, which are 80,000 lbs. tensile, 38,000 to 40,000 lbs. elastic, and 28 per cent. to 32 per cent. elongation. The three basic open-hearth furnaces use dolomite and calcined limestone to give a fusible cinder, the fuel being Connellsville coke.

In the steel foundry, which produces about 12 tons per day, the company have turned out castings weighing up to 110,000 lbs. The casting pit is 30 ft. deep by 10 ft. wide on top, and 16 ft. underneath

It is served by two cranes, each of 75 tons capacity, besides two pneumatic and one electric 50-ton cranes, one of 25 and one of 90 tons.

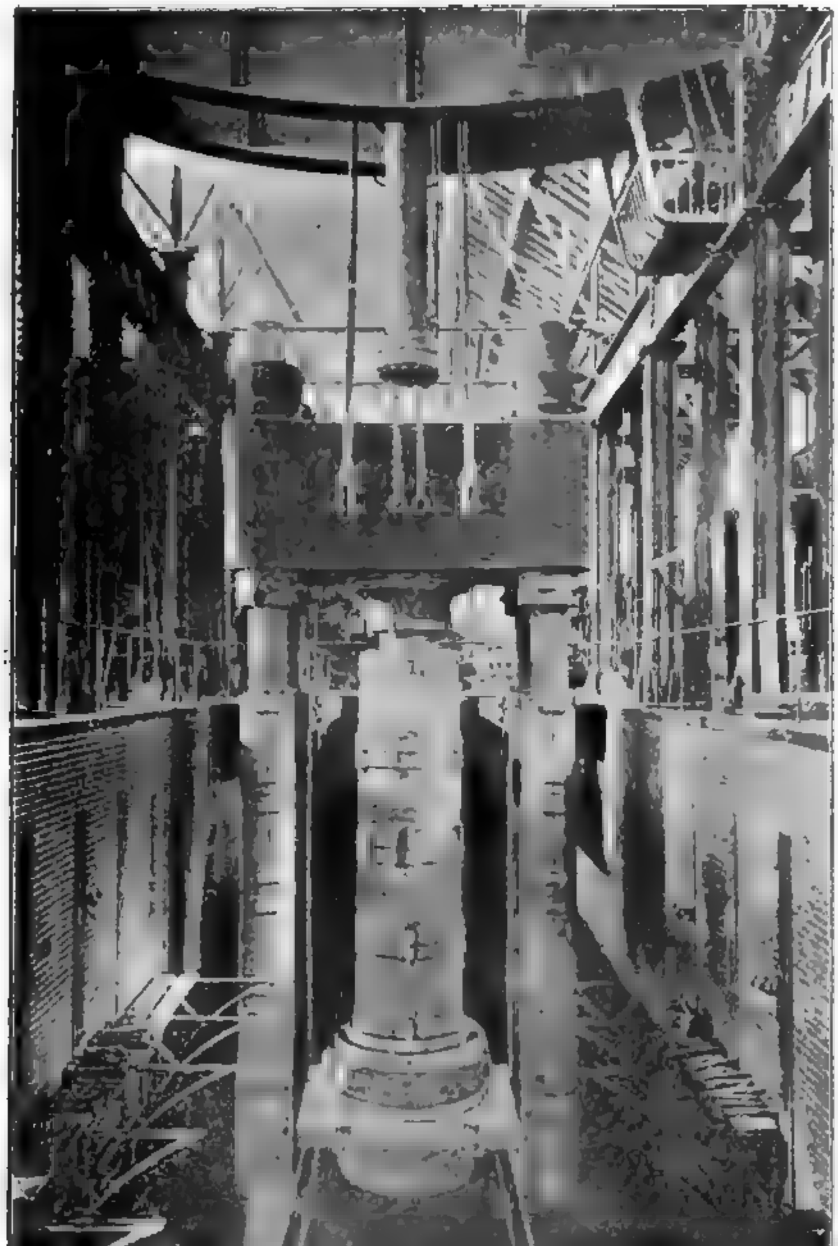


FIG. 44.—LARGE FORGING PRESS AT THE BETHLEHEM WORKS.

The castings are produced in a large space adjacent to the open-hearth furnaces, but under the same roof. There are two groups of open-

hearth furnaces, of which one group only is served by the Wellman charger. At the steel works and at the engineering shops, the bonus system is in operation, varying according to the class of steel produced.

At Bethlehem I was informed that the use of the Wellman charging machine had enabled the company to dispense with the services of about 20 men at the four furnaces which it serves, including the stock yard, etc., and making allowance for the men who are now called in to start the furnaces, which, being done simultaneously, involves calling in the occasional services of 12 to 15 labourers besides the furnacemen now regularly employed.

Sunday labour is common and is paid for at the rate of time and a half. My colleagues and myself went over the blast furnace plant at Bethlehem, and witnessed, among other things, the casting of pigs by Uehling's machine, but there is nothing about the plant to call for particular notice.

I cannot take leave of the Bethlehem Works without acknowledging, on my own behalf and that of my colleagues, the very hospitable treatment accorded us by all the officials, and the kindly authority given by Mr. C. M. Schwab, as proprietor, to be shown over. We were all glad, also, to have the opportunity, while at Bethlehem, of meeting my old friend, Mr. John Fritz, to whom the Bethlehem Works as a whole are a notable monument. *Si monumentum quaeris, circumspice!*

SECTION VIII.

CHAPTER IX.

Trusts and Consolidations.

General Remarks.

DURING the last few years, the so-called "Trust" movement has bulked largely in the industrial affairs of the United States. The iron and steel industry has had a larger share of the attentions of the trust promoters than almost any other, and probably no other industry is more liable to be affected by the general character and operations of the trust movement in the future. Hence it appears to be essential to a correct understanding, both of the present situation and of the future prospects and conditions of that industry, that this influence should be dealt with.

A recent writer has declared that, in general, "trusts are taken to mean manufacturing corporations with so great capital and power that they are at least thought by the public to have become a menace to their welfare, and to have, temporarily at least, considerable monopolistic power."*

There are many different methods of so organising industry as to limit competition at home and widen markets abroad, coincidently with controlling production and prices. Some of these that have been adopted more or less extensively may be indicated :—

1.—The system of pooling all contracts, whether on national or international lines, as in the case of the Rail Association, which flourished in Europe about 20 years ago.

2.—An agreement under which each manufacturer contracts to produce only a certain volume during the year, as in the case of the German Coke Syndicate.

3.—An agreement under which each manufacturer undertakes to pay an assessment on each unit exported, so that by relieving the home market of its surplus, domestic needs can be remuneratively filled.

4.—Definite agreements to fix the price of the product or divide the markets, which are very common, but rarely last long.

5.—The assignment of interests in different corporations or firms

* *The Trust Problem*, by Jeremiah W. Jenks, p. 8.

concerned, to a certain number of trustees, giving power of attorney to vote the stock as they may see fit.

6.—The establishment of separate corporations, as in the case of the Standard Oil Company, under which the holders of trust certificates are given shares *pro rata* in each.

7.—A voting trust, usually applying only to one corporation.

8.—A form of organisation owning the separate plants outright, leaving the legal aspect of the new single corporation similar to that of the separate corporations which preceded it.

The earlier and more elementary form of trust was merely an understanding that a certain number of competitive concerns should agree as to how much each should produce, so as to avoid over-production, and what common prices should be charged to consumers so as to secure a reasonable profit, but in all other respects each party to such an agreement was left absolutely free.

It was, however, in a large number of cases, found that the parties to such agreements could not easily be kept true to the letter and the spirit of the bond, and hence, as I have elsewhere pointed out, "it was for the purpose of avoiding such possible acts of bad faith on the part of the individual members of a combination that the American institution, known as a trust, was established."* The basis of this system was the transfer of a number of businesses for an agreed period to an executive, who ran them in the interests of the whole, with practically unlimited authority.

In 1889 I wrote in *The Times* that the success that had attended the development of this phase of the trust system had been so marked that "we may, if present appearances are not deceptive, live to see the food that we eat, the clothes that we wear, the railways upon which we travel, the ships in which we sail, and the labour which we employ, controlled by these organisations." Since then this anticipation has come much nearer to realisation than could have been believed probable at that time. The system at that time, however, was liable to be put down by the strong arm of the law, both in Europe and in the United States.† It became, therefore, necessary for the trust to actually own the various properties syndicated, in order to comply with the law, whence was evolved the latest type, described as industrial consolidations.

The United States Steel Corporation.

A new and as yet somewhat unmeasured force was introduced into the competition of the United States, alike for home and for foreign markets, by the consolidation, in the winter of 1901, of the [illegible] properties that now constitute the United States Steel Corporation. This body was incorporated in February of that year with an authorised capital stock of 1,100 million dols., of which 550 millions [illegible] per cent. cumulative preferred, and 550 millions [illegible]. The corporation practically owns the whole of the

[illegible]" (p. 9), in *Social Questions of the Day Series.*

[illegible] trusts came under the old statutes as to "forestalling [illegible] State Legislatures adopted legislation to get rid of [illegible] Code (Art. 419) prohibits any combination for the purpose [illegible]

stock of eight previous consolidations, named below, and of the Carnegie and Lorain Companies, with iron ore and coal mines, natural gas supplies and coke works, and other properties. The ostensible immediate occasion of the consolidation was the intimation that the Carnegie Company had arranged to extend their competitive resources for the production of tubes, etc., on a scale and in a location that would have involved detriment to existing manufacturing interests.

According to figures collected for his valuable *Directory of the Iron and Steel Works of the United States*, and of which, during my stay in Philadelphia, Mr. James M. Swank, the courteous secretary of the American Iron and Steel Association, handed me an advance copy, the resources possessed by the United States Steel Corporation are mainly as follows :—

EXTENT OF CAPACITY FOR MAKING PIG-IRON AND STEEL.

Corporation.	Pig-iron. Tons.	Steel Ingots. Bessemer. Tons.	Steel Ingots. Open-hearth. Tons.
Carnegie Steel Company	2,740,000	2,000,000	1,900,000
Federal Steel Company	1,855,000	1,760,000	240,000
National Steel Company	2,325,000	2,100,000	110,000
National Tube Company	605,000	480,000	—
American Steel and Wire Company	1,030,000	935,000	365,000
American Steel Hoop Company	500,000	--	10,000
Republic Iron and Steel Company	545,000	350,000	82,500
Lorain Steel Company	400,000	550,000	—
American Sheet Steel Company	--		247,000
American Bridge Company		---	230,000
Totals	10,000,000	8,175,000	3,184,500

Of finished products, the productive capacity of the works controlled by the United States Steel Corporation is estimated to be as under :—

	Tons finished products
Carnegie Steel Company	3,866,200
Federal Steel Company	2,360,000
National Steel Company	2,000,000
National Tube Company	996,000
American Steel and Wire Company	2,645,000
American Steel Hoop Company	730,000
American Sheet Steel Company	920,550
Republic Iron and Steel Company	1,043,000
American Tinplate Company (black plates)	534,750
Lorain Steel Company	506,000
Shelby Steel Tube Company	44,600
Troy Works	275,000
Total	15,921,100

The estimate of capacity in finished steel is so much in excess of the capacity of output in pig-iron and steel ingots that I was disposed to doubt its accuracy when it first came before me, and I therefore again went carefully over the figures, which, however,

appear to be accurate, according to the information given to Mr. Swank. The figures show that the capacity of output in finished steel of all kinds is about 60 per cent. in excess of the capacity in pig-iron, and nearly 40 per cent. above the capacity in steel ingots. The future policy of the corporation in adjusting these differences has not yet been declared, but the obvious reflection is that the powers of production possessed by modern rolling mills are so enormous that this is no new thing.

In the following table I have abstracted from Mr. Swank's *Directory* for 1901, details of the resources possessed by the Steel Corporation in certain leading products, so far as they are given:—

PARTICULARS OF CAPACITY FOR MANUFACTURING SOME LEADING PRODUCTS.

Tinplate Works—Built	11,492,000 boxes
" " Building	312,000 "
Total	11,804,000 boxes

Sheet Works—Plain and Black Sheets ...	530,000 net tons
" " Galvanized Sheets	160,000 " "
" " Large and Small Sheet Bars	192,650 gross tons
Bridge-building Works	441,200 " "
Seamless Drawn Tubes	63,000,000 feet
Car Axles	90,000 gross tons
Wire Rods	1,310,000 " "
Wire	1,562,500 " "
Pipes and Tubes	976,000 " "
Spikes	30,000 " "
Wire Nails	12,385,000 kegs (100 lbs)
Cut Nails	550,000 " "

So far as raw materials are concerned, the Steel Corporation appear to have secured sufficient supplies to guarantee them against possible scarcity or probable high prices for many years to come. In the Connellsville region they have 18,000 coke ovens already built, and several other plants are, or were at a recent date, in course of construction, while they claim to have secured three-fourths of the best coking coal lands. Not only so, but they have quite lately purchased large tracts of coking coal land in other regions that will supplement, and no doubt considerably extend the life of, their Connellsville supplies. According to Mr. Swank's figures, they own nearly two-thirds of the mines and mining output in the Lake Superior region, having 48 mines in the Mesaba, 24 mines in the Menominee, 11 mines in the Gogebic, 15 mines in the Marquette, and 8 mines in the Vermilion ranges, or 106 mines in all. In some of these mines they only hold a part interest, but of many of the most productive and important they are the absolute owners. For limestone supplies, they hold several large properties in different parts of Pennsylvania, one of them with a daily capacity of 4,500 tons.

A valuable asset of the corporation, which is properly ranked under the head of raw materials, is the large interest held in natural gas supplies and plants in Pennsylvania. In and around Pittsburg, and other localities, they have 132 wells, yielding natural gas to the extent of 11,000 million cubic feet per annum. This is a most

important addition to the materials at the disposal of the company, as natural gas is not only an economical and pure fuel in itself, but its use under suitable conditions enables a good deal of labour that would otherwise be required for stoking, removing ashes, and other purposes, to be dispensed with.

In Great Britain, many manufacturers are familiar with the fact that even the most desirable and ample supplies of raw material are liable to be discounted without suitable and moderately cheap transport. The Steel Corporation have taken care to secure this desideratum both on land and on water. They own, or they hold a controlling interest in, five lines of railway, of about 690 miles in extent, which to a large extent renders them independent of outside influences on rates. They also control about forty lake ore-carrying vessels, having a total season's capacity of about 3½ million tons of ore. And, finally, they own or control several docks at Conneaut, on Lake Erie, which renders them independent of the possible caprice of dock or shipping companies.

It is difficult to convey to the average mind an adequate idea of what the output of iron and steel here shown represents. Ten million tons of pig-iron represents the handling of probably about 30 million tons of raw materials in the form of iron ore, coal and coke, and limestone, and, assuming 1½ tons of coal to the ton of coke, it would mean an output of probably 15 million tons of coal alone. Then, again, the production of about 11½ million tons of steel ingots and nearly 16 million tons of finished steel represent operations of so colossal a character that they mark a new epoch in the history of industry. The capacity of finished steel output of the Steel Corporation is equal to the total actual production of finished steel in the whole of Europe, and is nearly 60 per cent. more than the greatest actual annual output of finished steel hitherto reached in the United States.

While these are the leading features of the possessions and resources of the United States Steel Corporation, as gleaned from Mr. Swank's recently issued Directory and from other sources, it must not be assumed that they are absolutely up to date, since additions to the different plants, and the improvement or demolition of plants that are not considered suitably located or up to date, are continually in progress, and the conditions necessarily change, not only from month to month, but almost from day to day.

The Steel Corporation had hardly been established when it undertook the work of centralising the operations of the various constituent companies as far as possible, increasing the resources of the larger plants that were favourably placed for particular branches of industry, and dismantling the smaller plants that could not be so economically worked. This process still goes on, and its natural tendency is to secure all the advantages of economy of production on a large scale, including a notable reduction of the costs of administration.

The Steel Corporation Considered as a Monopoly.

One of the most important of the many interesting problems raised by the establishment of the Steel Corporation is that of how

far it controls the iron and steel-producing capabilities of the United States. It has been suggested, and, indeed, distinctly alleged, that the Steel Corporation controlled so large a share of these resources that it held the future of the American iron industry in the hollow of its hand, and the outlook for the independent manufacturer has been described as doleful and discouraging. In short, the question raised amounts to this: Is the Steel Corporation in any very essential aspect a monopoly, or is it not?

In attempting to reach a reliable conclusion on this matter, it is important to distinguish between raw materials and manufactured or semi-manufactured commodities. The possible supply of raw materials is in all cases limited. There is no essential limit to the supply of manufactured products, given the conditions required for their production. At the present time, the Steel Corporation controls a very large share of the iron ore supplies of the Lake Superior region. It also has control over all but a very small part of the available supplies of the best Connellsville coking coal. These are at the present time the main sources of the raw materials consumed by the American iron industry. If my information is accurate, there is not much likelihood of equally important supplies becoming available for competitive concerns, although those competitors are in some cases possessed of what are equally satisfactory supplies. On the other hand, no one can say what a month or two may bring forth in the way of increasing the ascertained supplies of both iron ores and coking coal. The various iron ore ranges now being worked on Lake Superior are said to have been pretty well explored, and doubt is cast on the chances of finding new sources of supply of any great importance. But the United States as a whole, and the southern States in particular, have enormous iron ore deposits that are still virgin, and which can be, and no doubt will be, brought into use as necessity demands, although this may involve the displacement of Pittsburg as the centre of the American iron industry. As regards supplies of coking coal, the fields of Western Virginia, Pocahontas, Kentucky, Tennessee and Ohio will take care of this requirement for an indefinitely long future.

In respect of the resources of production of pig-iron and steel, the proportions of the total national capacity possessed or controlled by the Steel Corporation appears to be less a matter of controversy. *The Directory of the Iron and Steel Works of the United States*, issued in 1902, shows that at the end of 1901, the total blast furnaces available had an annual capacity of 24,812,037 tons per annum, while the blast furnaces of the Steel Corporation had a capacity of 9,900,000 tons a year. Hence it would seem that the Steel Corporation had just 40 per cent. of the total pig-iron making capacity of the country under control. From the same source I learn that while the total annual capacity of the Bessemer Steel Works of the United States was 12,938,000 tons of ingots, the Steel Corporation controlled 8,375,000 tons of this quantity, or about 65 per cent., while as regards open-hearth steel, the total national capacity of production was 8,289,750 tons, of which the Steel Corporation controlled 3,184,000 tons, or 38 per cent. Taking Bessemer and open-hearth steel together, the

total capacity of the plants at the end of 1901 was 21,218,000 tons, while the capacity of the plants controlled by the Steel Corporation was 11,559,000 tons, being a trifle over one-half of the whole.

In finished products the Steel Corporation occupies a more commanding position than it does in relation to either pig-iron or steel ingots. The total capacity of the United States in finished products is estimated by Mr. Swank at about 28 million tons, while that of the Steel Corporation is nearly 16 million tons, so that the Steel Corporation controls about 58 per cent. of the whole. But unless the corporation largely increases its means of output this is likely to be a relatively smaller proportion, in view of the large number of new plants now or recently being built to work independently, and in any case it is clear that the excess of capacity for the production of finished products over that for the production of pig-iron and steel ingots is not of much advantage in the way of giving control over the trade, since, in order to utilise that excess, pig-iron and steel ingots, blooms, and billets, must be purchased in the open market.

Financial Questions.

It will hardly be expected that I should deal with the abstract principles which regulate the consolidation of manufacturing interests on the lines of the United States Steel Corporation. This is far too large and weighty a matter to be handled here, even if it did not involve questions of a more or less controversial character. It may, however, be pointed out that the methods employed are apparently so simple and so readily applicable, that the system may easily be carried much farther. In such consolidations very little capital has to be raised—scarcely more than is needed to carry through the details of the deal. The financial basis of the arrangement is that of an increase in the nominal value of the interest held by the owners of the properties consolidated, and it is even possible to conceive of such an enterprise being launched without any capital being raised at all. Hence there has been a considerable extension of the system since the Steel Corporation was founded, although that is only a few months ago, and there have been attempts made to form another large consolidation of concerns outside the Steel Corporation, in order to introduce effective competition, if not to contest its supremacy. At home the same principles have been applied to the consolidation of the Dowlais and Nettlefold Works with those of the Patent Bolt and Nut Company, and it is reasonable to anticipate that we shall soon witness other deals of the same kind.

Since the Steel Corporation was founded, there has been a good deal of criticism of their capitalisation, which is about 74¼ million dollars in excess of the total capitalisation of the separate companies of which it was formed, excluding the Carnegie Company and the companies taken in since the organisation. It is claimed, on the other hand, that the test of value of any property is its dividend-yielding capacity, and that the Steel Corporation, judged by this standard, is not at all likely to suffer. It is undoubtedly true that the corporation has hitherto been financially successful—probably much more so than was generally anticipated. That, however, can hardly be attributed to any conditions within its sphere of influence. During the whole of 1901,

the American iron trade has been enjoying a phenomenal boom. The demand for iron and steel of all kinds has been so large that existing plants have been kept working to the utmost extent of their capacity. This of itself is no small advantage in estimating profit possibilities. But the Steel Corporation have also enjoyed the advantage of a high range of prices that was not in any way forced by their own action, and which they did but little to control. Speaking generally, as compared with the slump period of 1895-98, the average prices of 1901 show an advance of about 25s. per ton on pig-iron, and 40s. per ton on rails, blooms, and billets. The Steel Corporation has therefore had the most of this difference to the good, in addition to the profits earned in the low-price period referred to, for it will not be overlooked that, controlling, as they do, their raw materials and transport, they are not liable, like concerns otherwise placed, to have these advanced in price *pari passu* with advances in the prices of manufactured products. An increased profit of 25s. per ton on the pig-iron capacity of the corporation would alone yield over £10,000,000 sterling, and this sum may not unreasonably be doubled to represent the further profits that may be charged to the differences in the prices of finished steel. Here, then, we have, as compared with the prices that have actually prevailed in times of depression, a possible increase of profit of not less than 20 millions a year, which difference alone would be sufficient to yield about 9 per cent. per annum on the whole capitalisation of the corporation.

These figures are not submitted as pretending to absolute accuracy—except in so far as price differences are concerned—so much as for the purpose of illustrating actual and possible conditions that must greatly influence the future, not only of the Steel Corporation, but of other similar organisations. From an official paper handed to me in his office, in New York, by Mr. C. M. Schwab, and since republished in some American journals, I find the net earnings of the Steel Corporation for the first six months of its existence stated at about £11,000,000, or at the rate of £22,000,000 a year. During part of this time, the corporation was hampered by a strike, but Mr. Schwab's chief object in placing the figures in question before my colleagues and myself was to show us that the strike had not much affected the net profits, which, indeed were larger during August, when the strike was "on," than in some earlier months before the strike broke out. Is it not, then, justifiable to assume that if the Steel Corporation only earned £11,000,000 sterling as net profits in six months of such good trade as that above specified, when they might be expected to have a chance of earning at least £20,000,000 sterling a year in excess of the actual prices current in depressed times, the apparent possible profits under ordinary conditions and former prices in those times would, *ex hypothesi*, not exceed £2,000,000 sterling, subject to modifications in wages and a few other charges, which would hardly do more than pay 2 per cent on the £110,000,000 sterling of 7 per cent. cumulative preferred stock? And if the Corporation had to face six or seven years of bed-rock prices on these terms, where would its prosperity be, and how would its chances of continued life be affected?

It seems to me that these considerations, although necessarily more or less speculative, have an important bearing on the question of what part the Steel Corporation and similar organisations will be likely to play in the future competition for outside markets. They suggest questions as to the policy that may be pursued in reference to the dumping of large quantities of iron and steel on foreign markets without profit, and, perhaps, at an actual loss. At the same time, as the policy of the corporation is to bring up its works and operations to a higher condition of efficiency, and to rigidly enforce the law of the survival of the fittest, they may be able to show much better profit possibilities in the future.

Competitive Enterprise.

The situation of the United States Steel Corporation is, of course, largely controlled by their capital requirements, and by the prices at which they can afford to manufacture and sell their productions. That the capital is much in excess of the ordinary relation of expenditure to product is patent to everyone who has the least idea of what it would require to replace the existing mines, works, and other property belonging to the corporation. It has been computed that it will require about 20s. per ton of steel output to pay interest on the corporation's professed capitalisation, at the rate of 7 per cent., whereas other competitive concerns, such as Jones & Laughlins of Pittsburg, and the Lackawanna Iron & Steel Company, can possibly get off with 4s. to 6s. per ton of steel produced, their capacity of output in relation to their nominal capital being much greater. This, however, is not the only test, and it may not even be the best one. If the Steel Corporation, or any kindred concern, has stores of raw material relatively greater and better than others, the fact justifies a larger capitalisation per unit of manufactured products.

The fortunes of the Steel Corporation must in future be largely affected by the organisation and operations of competitive concerns, which are springing up in every iron-making district of the United States.* It was stated that the various constituent companies forming the Steel Corporation, previous to their consolidation, had prepared to spend some 325,000,000 dols. during the following five years, in making additions to their plants and resources for the purpose of competition with one another. It was assumed that by the fact of consolidation this expenditure would not be incurred. However this may be as regards the companies in question, it is undoubtedly the fact that since their consolidation took place a much larger sum has either been expended or provided for by other companies that are now rivals, and that this rivalry will in the future be keener than ever.

In this connection, the specific case of the National Tube Company is instructive. That concern is understood to have made very large profits as an independent concern by the operation of only 67 per cent. of its available plant. Mr. Carnegie made up his mind to have a large share of this business, when the launching of the Steel Corporation stayed his hand. It was assumed that this combination would

* See later remarks on this subject.

restrain future competition. Has it done so? When I was in Pittsburg, Mr. Julian Kennedy gave me a long list of competitive works that are either extending their resources, or being newly laid down to compete with the Steel Corporation.*

In the month of March, 1901, the *Iron Age* declared that a very serious danger had been escaped in the iron industry by the formation of the United States Steel Corporation, which had averted the pending battle of the giants. "That struggle," it was added, "would have led to a wholly unnecessary and fearfully costly duplication of plants. With one interest going into the manufacture of tubes and sheets, another threatening to invade the rail makers' field, a third getting ready to roll plates, a fourth preparing to build a large structural plant, a fifth about to roll and draw wire, there would not have been a single important branch which would have escaped the most savage competition. With every interest not provided with furnaces and steel plants seeking to fill that gap, and with every steel maker endeavouring to capture a market by finishing, we should have had excess capacity, unmanageable and unprofitable, for decades to come. It would have been a fearful waste of money, while the destruction of earning power and the suffering to labour, would have been unparalleled in the industrial history of this country."

I would venture to doubt whether the able editor of the *Iron Age* is still of the same opinion, in view of the extraordinary activity in the building of new plants of every kind, and the numerous pending projects looking to others, that have since been apparent on every hand.

The feeling of a large number of American representative business men, with whom I held conversations in the United States, appeared to be that the Steel Corporation is not likely to have a smooth course ahead of it. There is, to begin with, an instinctive dislike of what are called "trusts" on the part of the general public, and although the Steel Corporation is not a "trust" in the ordinary sense, it is a combination with a vast influence over production and prices, which, to the man in the street, means the same thing. A number of States have initiated drastic legislation against trusts—New Jersey being, indeed, almost the only State that deals with them gently. President Roosevelt himself deemed the trust system a matter deserving of special notice in his recent Presidential address, and there are known to be both Senators and Congress-men who would be glad to see Federal laws enacted against them. Apart from this, however, as one of my friends reminded me in New York, the trusts are in a vicious circle, and it is difficult to get over the dangers due to meeting the constant increase of competition from new plants which are springing up, and likely to continue to spring up, while the Steel Corporation continues to earn only fairly respectable profits. In some cases such plants have been purchased by the Steel Corporation, or their competition has been otherwise bought off, as already shown. But there must necessarily be a limit to this, especially as there is more than a suspicion that certain works have been undertaken with a special eye to being bought

*See previous remarks on Tube Manufacture.

out at a fancy price. Indeed, not long after the earlier consolidations of steel plants began three or four years ago, a number of new works were built in the United States, some of them, according to the *Iron Age* (June 24th, 1901), "with the deliberate purpose of being sold out to the consolidation at which they were aimed." Some of these new plants were almost immediately bought up, because their competition threatened to be formidable, and the Steel Corporation cannot expect to have much control over prices if it allows the outside manufacturers to have anything like an equal influence with themselves—a point to which present appearances are tending.

The Measure of Value.

In considering the capitalisation of the Steel Corporation and similar concerns, the correct view of value is not what the properties have cost their actual owners, but the price at which they could be replaced—if they could be replaced at all. This last reservation is necessary, because much of the property owned by the corporation could not be replaced. This is more particularly true of their holdings in the Connellsville coke region, and in the Lake Superior mines. Mr. Lynch informed me that most of the corporation's coke lands in the Connellsville region were acquired at 300 dols. per acre, that the last purchase cost 1,200 dols. per acre, and that the present price is 1,500 dols. per acre for inferior areas. Hence it appears that thousands of acres of coal and coke lands alone have been purchased at one-fifth of their present value, which in this one item would appear to justify an appreciation of 500 per cent.

The Outlook of Prices.

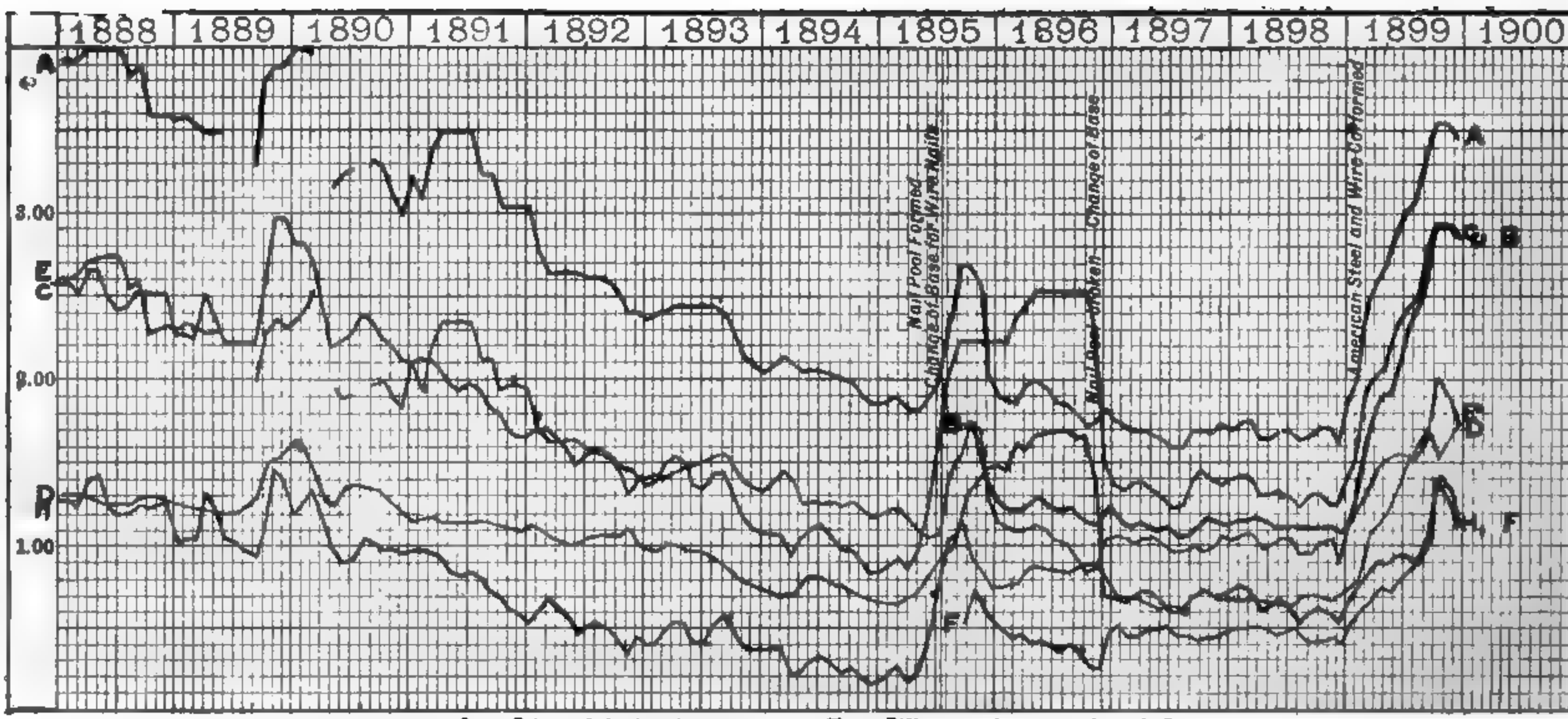
It is now some 15 years since I called attention to the influence of trusts on prices, and dealt with the subject in articles contributed to *The Times* and otherwise.* At that time there was much apprehension lest the growing power of trusts might create monopoly and raise the prices of commodities all round. Under the influence of this fear, trusts were entirely prohibited in a number of States, and the majority of them, as then constituted, had to be wound up. Nevertheless, the cases in which there was proof of a large increase of price were comparatively rare, and in some correspondence which I then had on the subject with Mr. S. C. T. Dodd, the solicitor, and Mr. J. H. Flagler, the vice-president of the Standard Oil Company, they submitted proof that the prices charged to the public had been largely reduced, instead of being raised during the life of that important organisation.

Many other trusts, or syndicated arrangements as to production, have been able to point to similar experience. The cases to the contrary have been few, and they have not by any means been the most successful. The well-organised and efficiently-administered combination of this kind aims, or ought to aim, rather at making its chief gains by steadying prices—without increasing them, and it may even be by lowering them—and by economising production. This has been the experience of the Standard Oil Company and similar organisations.

There are, of course, many possible means of reducing the cost of

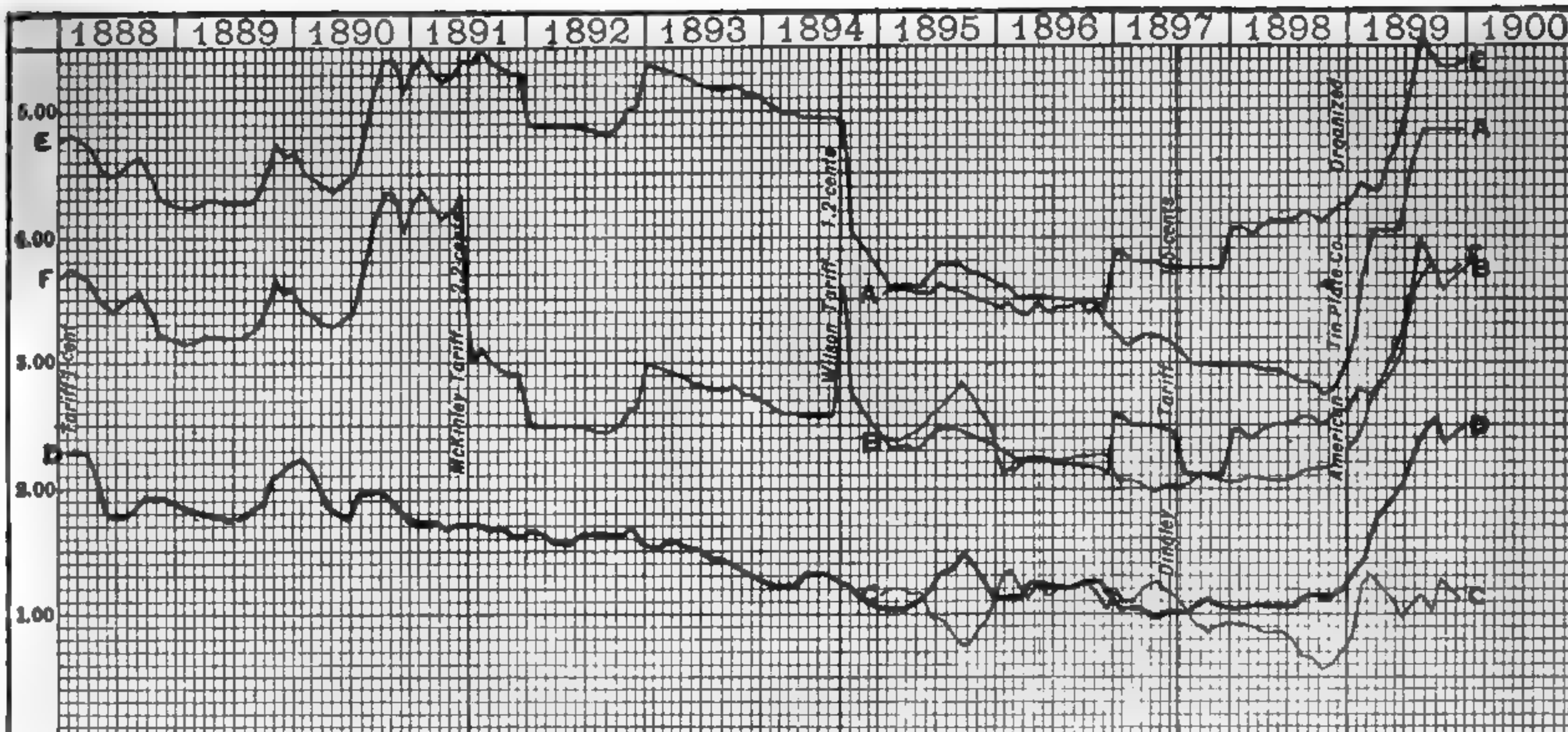
* *Vide* "Trusts, Pools, and Corners," in Methuen's *Social Questions* Series.

† Evidence tendered before a Committee of Congress of the United States.



A = Price of barb wire.
B = Price of smooth wire.
C = Price of wire nails
D = Price of steel billets.
E = Difference between A and D
F = Difference between B and D.
H = Difference between C and D.

FIG. 45.—MOVEMENT OF PRICES OF STEEL AND WIRE IN THE UNITED STATES, 1888 TO 1900.



G. TORRANCE, DEL.

A = Price of American coke tin plate per full weight box, at Pittsburg.
B = Cost of steel, plus tin, plus labor, for one full weight box of tin plate.
C = Difference between A and B, indicating course of profits.
D = Cost of 105½ lbs. steel billets at Pittsburg, plus 2½ lbs. tin at New York, the material for one full weight box of tin plate.
E = Cost of imported coke tin plate, per full weight box, laid down at New York, duty paid
F = " " " " " " " " " " " " " exclusive of duty.

Fig. 46.—Prices of Tinplates in the United States under Different Tariffs, 1888 to 1900.

production when operating on a large scale. Two sources of economy affecting the steel industries may be named among others—the one a saving in the cross freights, which the American Steel and Wire Company, through Mr. Gates, their president, estimated at 500,000 dols. a year, and the other a saving due to the avoidance of changes of the rolls in rolling mills, thus abating delays which would be attended by waste of time and energy under competitive systems. It may be noted that Mr. Guthrie, the president of the American Steel Hoop Company, estimated the economy due to this latter source alone at 4s. to 6s. per ton.*

The influence of the recent American consolidations on prices is to some extent indicated in the two charts presented herewith. The first shows the rapid increase in prices during the year 1899, in steel and in tinplates, as recorded in *Iron Age* quotations. Professor Jenks, to whose excellent work* I am indebted for these charts, has stated his opinion that the increase in the price of steel had necessarily forced up the prices of tinplates; that the price of steel had been increased by the enormous demand for new purposes; that since the Tinplate Trust was formed the increase in the price of American tinplate had not, on the whole, been greater than the increase in the value of the raw material, plus the increase in labour costs; and that from March, 1899, till the middle of 1900, which coincides with the first period of the Tinplate Trust's existence, profits were no higher, but rather lower, despite an increase in tinplate prices.

The movement of prices of steel billets, wire, etc., as a result of the establishment in January, 1899, of the American Steel and Wire Company, is equally instructive. In November, 1898, a strong upward movement began in the price of steel billets, followed in the succeeding month by an increase in the price of wire nails and by an increase in the wages paid in the wire industry. This was concurrent, up to a certain point, with a "decided increase in profits," but, on the whole, Mr. Jenks is of opinion that even without any trust, "there would have been an increase in the margin between the crude and the finished products, owing to the enormous demand," and he adds that "the great increase in the price of finished products is due chiefly to the increase in that of the raw material."†

So far as the operations of the Steel Corporation are concerned, it is generally admitted that in matters of price they have followed out what Americans describe as a "conservative policy." Prices, it is believed, have not, on the whole, been raised above the level that they would have reached in the current circumstances of trade, had the Steel Corporation not been in existence. The prices of raw material have been kept moderately low, considering the urgency and vast extent of the demand. On the other hand, it is not generally anticipated that the corporation will suffer the prices of coal, coke, iron ore, and other materials, so far as they can prevent it, to fall to the unremunerative and unprecedented level of a few years ago, and if this position is strictly adhered to by the corporation, it must react on the attitude taken up by independent operators. Whether this forecast and prospect will equally apply to foreign business remains to be seen.

* "The Trust Problem," p. 163.
† *Ibid.*, p. 170.

SECTION IX.

CHAPTER XII.

The Basic Steel Industry.

I UNDERTOOK special inquiries at several leading basic steel works—among others those of Homestead, Duquesne, Ensley (Ala.), and the Lukens Company at Coatesville—as to the conditions under which the basic steel industry is carried on.

The Basic Process at Homestead.

In going over the basic steel plant of the Homestead Works, in which I was accompanied by Mr. W. A. Bostwick, and who last year assisted to set the Monell system at work at the Cleveland Steel Works of Bolckow, Vaughan & Company, I learned that all of the 48 open-hearth furnaces operated produced basic steel, the output of which is about 100,000 tons per month. The furnace capacity is one-half 40 tons and one-half 50 tons each. When sufficient supplies are available 25 per cent. of the whole charge is scrap. The mill iron contains about $\frac{4}{10}$ per cent. P., and when running both pig-iron and scrap the P is raised to $\frac{6}{10}$ per cent. A considerable quantity of basic open-hearth cinder is also used, which acts as a cheap flux, as well as roll scale, heating furnace cinder, and other more or less waste products of the steel works. The whole burden of the ore used will run ·22 to ·25 per cent. of P.

The ore used varies considerably in its content of phosphorus. It is mostly got from the Mesaba range, in the Lake Superior region. The average phosphorus in the finished basic steel produced at Homestead is ·040, and this is the figure generally arrived at. The steel is treated in a mixer, which is lined with magnesite and dolomite. The bottom in this mixer lasts for a considerable time, the same bottom having been in for nearly three years. Basic additions are employed to neutralise the blast furnace slag only. The mixer is a reservoir only, and no chemical action goes on in it. The mixer is, I believe, the first of its kind; it is gas-fired, suspended on a curved rack; and the ports roll with the vessel. A duplicate mixer, I was informed, has recently been erected at the Port Clarence Steel Works on the Tees.

The mixer is only capable of dealing with about one-half of the basic steel produced, and it is so placed as to suit the convenience of the older plant, with the product of which it therefore deals. The steel produced in the newer plant is not put through the mixer, but the metal is poured direct into the open-hearth furnace as taken from the blast furnaces on the opposite side of the river. The open-hearth furnace plant is served by a Wellman charging machine.

The average life of the lining of the open-hearth furnaces working on basic steel is about 400 heats of 38 tons each in the old plant, and rather more in the new. The general average of the heat is about nine hours, and 16 heats per week is a usual average, including the operation of bottom-making. Very little trouble is found with bad bottoms, although these do happen, and occasionally during the heat of summer, when the workmen are less able to stand the work.

The ore and pig process, the pig-iron process, and the pig and scrap process, are all variants of the open-hearth process as practised at Homestead, the extent to which any one of them may be employed depending on such circumstances as the price and extent of supply of scrap, which sometimes runs so high as not to justify its use. When a high percentage of pig is employed the length of the heats is increased, and this leads the administration at Homestead to use a larger quantity of ore, whereby the duration of the heat is not increased, and the firm is rendered independent of the scrap market. This is regarded as the main value of the Monell process at these works, and it is used much or little according to the conditions.

A large part of the basic steel produced at Homestead Works, is supplied to the Pressed Steel Car Company of Pittsburg—the average being nearly 1,000 tons a day. This steel is made in accordance with a specification of ·15 per cent. to ·22 per cent. carbon. The steel so supplied must not be soft, and yet capable of standing cold flanging well. The P in this steel is about ·040 per cent. The Homestead Works also supply a good deal of material for car axles, which runs ·35 per cent. to ·42 per cent. carbon.

Natural gas fuel is almost exclusively employed at Homestead. Hence the remarkable freedom from smoke, dust, dirt and disorder which characterise the plants. The manager informed me that they did not consider natural gas a cheaper fuel than coal—which in the Pittsburg district is remarkably cheap, and is in many cases delivered at works for about 3s. 6d. per ton—but labour is saved in the handling of the fuel, and in cleaning out and removing ashes, etc. The gas is supplied by the Carnegie Gas Company, which is an independent concern that supplies this form of fuel to a number of works in and around Pittsburg.

As regards labour, I was informed that the ordinary 50-ton basic open-hearth furnace at Homestead is operated by three men—one a first helper, who in British works would be called a melter; another, described as a second helper; and the third a cinder pitman. The first helper is responsible for getting out the heat properly. A separate foreman is employed for each six to eight furnaces and he is responsible for the proper composition and tapping of the charge, temperatures, and other conditions. The duties of the second helper are to supply the necessary refractory materials, ferro, ore, etc., tap the heat, and make up the tapping hole afterwards. The cinder pitman looks after the cinder pit, and makes the bottom, etc. Another special man, who is under the control of the electrical department, looks after each charging machine, and there is one such machine to every four furnaces. A 50-ton heat is charged by one man and the charging machine in about half an hour.

The first helper (melter) is paid 5½ dols., and the second 3½ dols. per day. The metal is tapped direct into a 40-ton ladle. It may be added here that the works employ about 6,000 hands, not including the Carrie blast furnaces, which feed them with pig-iron, nor the adjoining Howard axle works, which use a large part of their products, and are of great extent.

From some of the 40-ton furnaces the week's product of ingots is as much as 850 tons, running 50 per cent. hot metal, and 50 per cent. scrap, in 23 heats.

The pig-iron employed at Homestead runs 1½ per cent. silicon, ·0·60 Mn, 0·40 S, ·090 P, and 3·75 to 4·00 per cent. C. For the open-hearth process the P in the pig-iron is about ·40 per cent., the silicon ·75 per cent.; the sulphur, ·040 per cent.; the Mn ·80 per cent.; and the carbon 3·75 per cent. to 4·00 per cent. In the open-hearth furnace the phosphorus is brought down to ·25 per cent. at the start, when running 50 per cent. pig and 50 per cent. scrap, and the heat finishes with P at ·025 per cent., so that there is an elimination of 90 per cent. The basic lining and additions show 6 per cent. to 7 per cent. of lime in the charge, or about 100 lbs. per ton of ingots. The bottom is repaired after each charge.

The general average output of different descriptions of steel is as under:—

Plates (two mills)	36,000	tons per month.
Billets and slabs	70,000	" "
Structural shapes	30,000	" "
Total	136,000	" "

Some of the output is duplicated by the fact that the plates are to a certain extent also included in the slabs.

In the Bessemer department, the output of commercial steel—blooms, slabs, and billets—is about 40,000 tons per month, from two converters of 11 tons capacity each, and two mills.

There are both night and day shifts at Homestead, of 13 and 11 hours respectively. The pig-iron is brought from the Carrie furnaces on the other side of the river, over half a mile distant, where the Carnegie Steel Company have recently rebuilt two furnaces, and were, at the time of my visit, rebuilding two others, which will yield a total daily output of over 2,000 tons, when the plant is completed. All the men are employed on tonnage rates except day labourers, so that it is practically the interest of everybody to get out as much as possible. The foremen are paid tonnage rates as well as a salary.

One feature of the Homestead open-hearth practice, to which a good deal of importance appears to be attached, is the use of dolomite instead of clay for the tap holes. In some cases, in British practice, anthracite and chrome ore are used, but at Homestead they have decided that dolomite and tar make the best plug.

The Homestead Works extend along the bank of the river for about a mile and a half, and their area is about 2,000 ft. wide at its widest point. The melting shops are about 1,100 ft. by 350 ft. The stock yards are about 150 ft. wide. Every department is spanned by overhead electric

cranes, at which 36 men are employed. At the open-hearth plants there are two electric cranes for each twelve furnaces, one 50 and the other 70 tons capacity.

The heads of this remarkable establishment are: Mr. A. C. Dinkey superintendent; and Mr. E. F. Wood, assistant-superintendent.

The Duquesne Steel Works.

The Duquesne Steel Works, which also produce basic steel on a large scale, are in several ways exceptionally interesting, but chiefly so as having been the first at which blast furnaces were erected that were specially designed to give a daily output of 500 tons and upwards, a figure which had hardly been approached up to that time. We were most cordially received by Mr. Hunt, the general superintendent, who, in answer to my enquiries, intimated that No. 3 furnace had, up to the date of our visit, produced the best daily output, namely, 752 tons, and had run 4,690 tons in the same week. The best month's run had been 19,630 tons, using 55 per cent. ore, taken from the stock pile. The best daily record of the whole four-furnace plant had been 2,649 tons, the best week's record had been 17,596 tons, and the best month's record was 73,258 tons. The coke consumption averaged 19·98 cwt. per ton of pig, and the ore was a mixture of Mesaba—35 per cent.—Gogebic, and Marquette.

Having in mind the considerable amount of discussion that has taken place at the meetings of the Iron and Steel Institute and elsewhere as to the extent to which rapid driving affects the life of a furnace, as measured by its total output, I asked Mr. Hunt if he could furnish me with the records of the Duquesne furnaces up to the date of my visit. He most kindly gave me the following figures:—

	Date of Blowing in.	Total Output to Oct. 1901. Gross Tons.
No. 1 Furnace	June, 1896	941,000
No. 2 „	October, 1896	877,000
No. 3 „	May, 1897	805,000
No. 4 „	June, 1897	787,000

"And," added Mr. Hunt, "we have made up our minds that they will each make 1,000,000 tons before we proceed to reline." These figures may be useful for comparison with British makes. My recollection is that 1,000,000 tons is rather a rare performance for a British furnace.

The Bessemer plant at Duquesne embraces two 9·6-ton converters, which have produced 2,268 tons of ingots in a day, 12,734 tons in a week, and 52,180 tons in a month. The general daily average output of ingots is 1,998 tons. The whole of this is rolled into blooms and billets, which are worked up into wire rods, tin bars and other products.

There are 12 50-ton open-hearth furnaces, which began operations in October of 1900. The daily average of this plant has been as much as 1,595 tons of ingots over a week. The best day's output was 1,710 tons, the best week's 9,174 tons, and the best month's 38,262 tons. These results are got with only 343 hands employed at the furnaces, working double turn. This means, assuming that the last-named records were maintained over a year, an annual capacity of about 460,000

tons of ingots for the open-hearth plant, and an average of 1,350 tons of ingots per employé at the furnaces.

There are altogether six mills at Duquesne, of which the more important are the 21-in., or old mill, the 16-in. or continuous mill, and the 40-in. mill. From the latter mill an output of 1,118 tons has been got in 24 hours of 6 by 4 billets. The old mill is usually occupied on tin bars, fishplates, small billets, and sheet bars. It has turned out 4,563 tons in a week of six days. The best run on sheet bars has been 759 tons. The 16-in. mill has produced 679 tons per day of 1½ by 2-in. billets. In this mill the same products can be, and sometimes are, rolled out in the 21-in. mill by a change of rolls.

In the new open-hearth department there are 10-in. and 13-in. mills. Bars have been rolled 450 ft. long. In a new mill, which had been at work a week at the time of my visit, it is proposed to roll squares and flats. In the older part of the works a gigantic new mill was being erected by the Morgan Company, which it was expected to have in operation early in 1902. The output of this mill is expected to exceed 1,000 tons of billets in the 24 hours. The principal mill is driven by a reversing engine, by Mackintosh, Hemphill & Company, of 12,000-h.p., which is guaranteed to reverse 70 times per minute. The live rolls from the soaking pits—of which there are nine, with four holes to each—extend for nearly 300 ft. Arrangements are provided which enable the steel to be taken to the lower mills in case of a breakdown at the upper ones. The ladles used are of 50 tons capacity, and the moulds hold two tons each. Five electric cranes are provided over the charging platform for unloading the scrap.

The Ensley Works (Ala.).

For a long period it was deemed doubtful whether the south would succeed in competing with the north and the central States in the manufacture of steel, and more particularly of basic steel. This idea was probably mainly founded on the fact that the first attempts to produce pig-iron in this region were not nearly so successful as was anticipated. With the first Ensley blast furnaces, 80 ft. high. and 22 ft. bosh, a daily output of 250 tons per day per furnace was looked for. Instead of that, however, the average reached was only about 100 tons, and that was got with very irregular working, causing the product to gain a reputation that was not good. But time has cured many of the early defects. In 1894, a blast furnace which was producing only 3,441 tons 12 months before, had got up to 6,091 tons, and better results have been obtained since that date. But the soft ore of the district is hardly favourable to large outputs.

The open-hearth plant at Ensley has several special features, one of the most notable being the fact that it is the first and largest installation in the States of the Wellman rolling furnace. There are 10 such furnaces, 33 ft. by 30, and capable of melting a 50-ton charge. The usual practice hitherto has been 10 heats per furnace. The furnaces are equipped with two Wellman low-level chargers.

In making basic steel at Ensley it is the custom to make use of 16,000 lbs. of limestone in a 50-ton charge, dolomite being used for

the hearth. The dolomite is found in abundance within a few miles of the works. The ore used in the open-hearth furnace is brought from Georgia, and contains 50 per cent. of iron, 1,000 lbs. being the maximum quantity for a charge, with 25 per cent. of scrap. Fluor-spar and roll scale are also used in varying proportions, with a view to a better flux and a more liquid charge.

The iron used in the Ensley open-hearth furnaces for the manufacture of basic steel runs about 0·57 silicon, 0·71 phosphorus, and 0·033 sulphur. The ordinary specification provides that the silicon shall not exceed 1 per cent., the phosphorus 1 per cent., and the sulphur ·05 per cent.

Out of 10 open-hearth furnaces built, the company have not hitherto had more than seven in operation at any one time, chiefly because of the insufficient supply of gas, which has led the company to make use of oil fuel in an experimental way, and with results that were well spoken of, the tonnage from oil fuel being asserted to be larger, while the supply can be better regulated. In furnace practice, a fore-hearth is used, and two ingots are tapped at one time. The standard size of ingot is 18 by 20, but 30 by 30 is also a common size, the weight being about 9,000 lbs. Ferro is added in the furnace, because there is no ladle, the quantity used to the charge being about 600 lbs. Each furnace has three charging doors, with removable ports, controlled by an auxiliary trolley. The producers used are of the Talbot-Frazer type, giving 24 per cent. of CO, and requiring about 2,000 lbs. of fuel every hour.

In the mill, the approach table in front of the rolls is operated independently of the ingot run. This facilitates the handling of ingots for which the mill may not be ready. The mill has two side-guards, which are movable, and operated by hydraulic cylinders, whereby the piece being manipulated is held edge-up, and which is termed a manipulator. The screw-down gear is operated by a 100-h.p. electric motor, and is quick-acting. The mill engine is an Allis-Corliss, of 36-in. cylinder and 48-in. stroke, geared one to two, with 10-in. pitch, the face gear being 36 in. Three men are employed in the pulpit—one for the engine, one for the manipulator, and one for the screw-down gear.

The auxiliary plant and appliances at Ensley do not call for special remark. They include the usual types of ladles, strippers, soaking-pits, etc., known in American practice.

The principal mill is a combined slabbing and blooming, with 80-in. rolls, served by reversing engines, 36 by 48, and can roll 36-in. slabs. The finishing mill produces structural shapes, eye bars up to 14 in., etc. A new mill, which was being built at the time of my visit, for the purpose of manufacturing rails, is, I believe, now in operation. The company have not made, and do not at present intend to produce, plates of any kind. I was informed that the company had contracted to supply 200 tons of steel per 24 hours to the adjoining wire works, at 20 dols. per ton, which for the last twelve months has been a more favourable contract for the wire works than for the steel works.

It will be judged from what has been stated, that the Ensley Works are not so well up to date as those to be found in the eastern and middle States. An inadequate supply of gas, the absence of a mixer and a ladle for charging additions to the bath,

the generally cramped character of the plant, and other features, appear to have combined to make it difficult to show the best that can be done in the way of producing cheap basic steel in the south. But the new president of the Tennessee Company is said to have made up his mind that the efficiency of the plant at Ensley shall be largely improved, and that the cost of producing steel shall be much reduced. Arrangements are now in progress with those ends in view.

In the best basic open-hearth practice, I heard that as many as 400 heats have been got out of a single bottom, using about 52 per cent. pig, and 48 per cent. scrap.

The conditions under which the basic open-hearth plant of Worth Brothers, and Lukens, at Coatesville, are operated, will be found described in the section dealing with the manufacture of plates.

General Remarks.

There can be no doubt that the basic process has a great future before it in the United States. This future is assured by the fact that all American engineers, excepting only one, have accepted basic steel for all ordinary purposes. The exception is the engineer for the new Brooklyn bridge.

The outlook of the basic process is also probably improved by the fact that the Monell process is understood to have, to some extent at least, solved the problem of the expulsion of carbon, while getting rid of phosphorus, by using a low temperature. This enables the carbon to be retained, but there are those who hold that the oxidation of the material is still carried on unduly.

The interviews that I had with a number of leading American engineers and metallurgists all point to the one conclusion, which one of them has thus expressed to me, namely: "The only salvation for British steel manufacturers seems to lie in the larger use of basic steel, and in getting British engineers to accept that description of steel for all ordinary requirements, equally with acid."

At the same time, as one of my American friends frankly acknowledged, this view may be coloured by a certain tincture of selfishness, because they cannot compete on equally advantageous terms for acid steel contracts, that description usually costing somewhat more to produce.

There is every probability that the American basic steel industry will increase very rapidly in the future. Most of the new open-hearth furnaces now being erected, so far as I have ascertained, are designed to produce this description. And, speaking generally, American engineers are prepared to accept basic steel equally with acid, although there may be a few unimportant exceptions. At the Ensley Works they are now beginning to roll rails of basic steel, and it is probable that this example will be followed elsewhere. At the same time, it will be noted that the character and composition, both of the raw material used, and of the pig-iron and steel produced, are so different to those common to British practice, that the conditions do not admit of exact comparisons. In one respect only do the two countries appear to be alike—both have vast supplies of ore that can be used for the basic process, although greatly different in composition and value.

SECTION X.

CHAPTER XIII.

Some Features of American Engineering.

It is not necessarily a part of this inquiry to examine from a technical, or even from a practical point of view, the conditions that differentiate the engineering practice and achievements of the United States from those of Great Britain. Nevertheless, it is essential that the economic aspects of engineering should be considered in relation to the progress that has been and is being made by American iron and steel manufacturers.

Much information on this aspect of American attainments and competition will be gathered from other parts of this volume. The character and the more prominent features of blast furnace equipment, steel works and their plant, foundries, and other establishments are indicated in the several sections that deal with these matters. Apart from these, however, there are many characteristics of American mechanical workshops and their practice that may be considered under the heading given to this chapter. In undertaking this task I cannot, of course, pretend to do more than deal with a few of the conditions of mechanical engineering that have a direct bearing on the iron and steel industries.

The mechanical engineering of the United States, for the special purposes of this enquiry, may be divided up under the following general heads :—

1. Iron Works, Rolling Mills, and Rolling Mill Plant.
2. Steam and Locomotive Engines, Hydraulic Appliances, and Electrical Plant.
3. General Machinery, and Machine Tools.

1. So far as rolling mills are concerned, the United States must by this time have had a unique experience of their construction and use. At the end of 1901 there were 527 mills in operation in the United States, representing an estimated capacity of over 23,200,000 tons of rolled products, against a maximum output of such products reaching 10,294,000 tons in 1899, and 9,487,000 tons in 1900; the capacity of the existing rolling mills at the end of 1895 having been 14,763,000 tons, so that the increased capacity in the intervening six years was about 8,600,000 tons of rolled iron and steel products, or within two million tons of the whole capacity of the Republic only 12 years ago.

The same remarkable advances are apparent in other branches of mechanical engineering, and not least so in engine building. The total number of blast furnaces in the United States at the end of

1901 is recorded by Mr. Swank as 406, and as the practice in American works is to have a separate engine for each blast furnace, and sometimes more than one, this may be taken as equivalent to at least an equal number of *blowing engines.* Then, again, Mr. Swank has ascertained that the total number of other establishments embraced within the elastic and far-reaching limits of the iron industry, were, at the end of 1901, as under—the figures for the end of 1895 being added for comparison :—

	1895.	1901.
Rolling Mills and Steel Works ...	505	527
Cut Nail Factories	53	43
Wire Nail Works	53	67
Bessemer Steel Works	43	35
Open-hearth Steel Works	88	112
Crucible Steel Works	45	45
Tinplate and Terneplate Works ...	69	55
Total	856	884

Here in the main branches of the iron and steel industries we find a total of 856 establishments in 1895, and of 884 establishments in 1901, which severally call for the installation of steam engines and electrical and other equipment on a more or less extensive scale.

This vast field for engine design and construction has naturally been cultivated with the energy, enterprise, ingenuity, and adaptability characteristic of American engineers, and while the different forms and applications are legion, the standard types are comparatively few.

Some Leading Types of Engines.

The principal makers of engines for iron and steel works are not numerous, although the number of makers of engines generally is very great, and, indeed, may be found distributed over the whole country.

One of the newest types is that of the Corliss blast engine (Fig. 47), which is in operation at the furnaces of the Schoenberger Steel Company at Pittsburg, and is an adaptation of the Corliss valve motion to the inlet air valves, while the outlet air valves are automatically operated and air-cushioned.

Another type is that of the Allis engines built for the Duquesne and other works by the well-known engine makers of that name. These are of the usual vertical compound condensing form with 28-in. and 42-in. steam cylinders, by 5 ft. 6 in. stroke. At Duquesne there are five such engines in pairs, with one pair in reserve (see Figs. 48 and 49). I was informed at Duquesne that these engines not proving quite equal to the work they had to perform, a new engine plant had been arranged for.

Among other types of engines that are largely in use in American iron works, mention may be made of the Southwark compound condensing engine (Fig. 50), the vertical cross compound blast furnace blowing engine of the steeple type, by the Allis-Chalmers Company, of which the one illustrated in Fig. 51 and Fig. 52 has 50-in. h.p. and 96-in. l.p. cylinders, 100-in. air cylinder, and 60-in. stroke; the horizontal single

blowing engine of the same firm, Fig. 53; and the Buckeye blowing engine, Fig. 54. The interior of a large blast engine-house, with a battery of Southwark engines, is illustrated in Fig. 55.

In mill engines well-known types are those of the even-geared and of the differentially-geared reversing engine. It is claimed for the former that they have some of the advantages of the direct-coupled

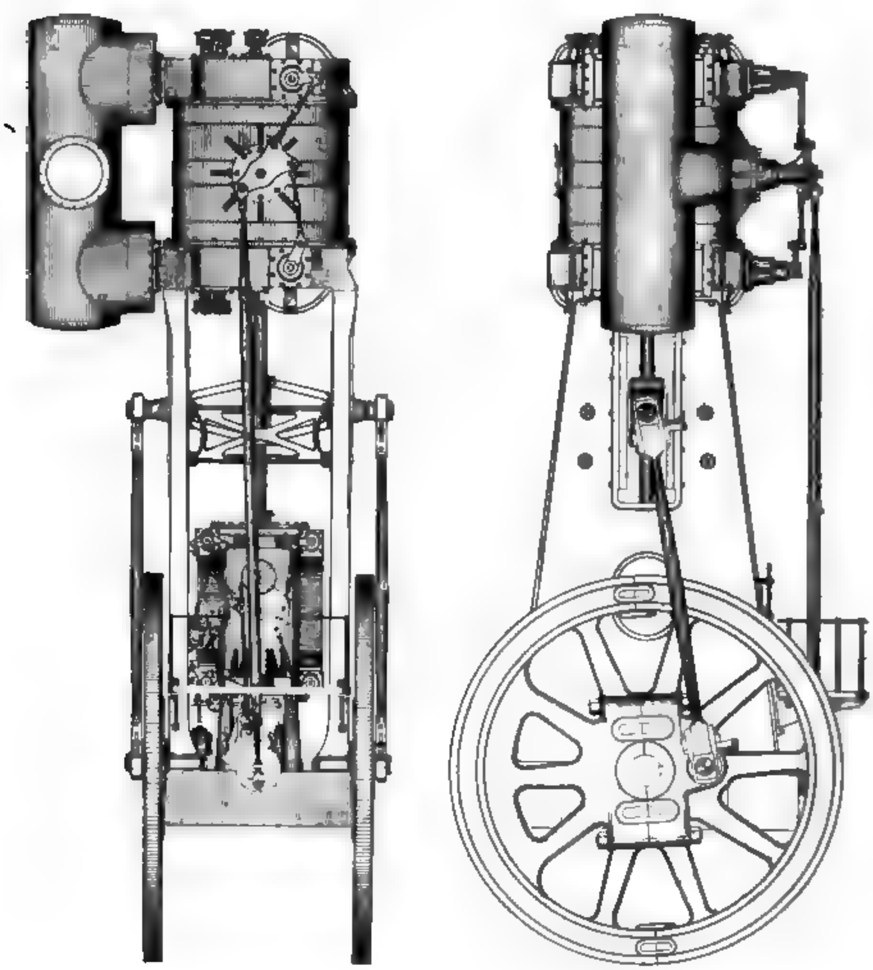


Fig. 47.—Corliss Blast Engine.

reversing enginess without their heavy cost, while they are sometimes preferred where it is desired to get the full power required by the mill without increasing the power of the engines by the intervention of differential gearing (see Fig. 56). The differentially-geared engine is a type ordinarily used in reversing mills, and is to be found in a majority of American steel works. It may be geared at varying ratios with the mill of three to one, seven to six, etc., and fitted with piston valves (Fig. 57).

The direct-coupled reversing engine shown herewith (Fig. 58) is in operation at some of the leading steel works in the United States,

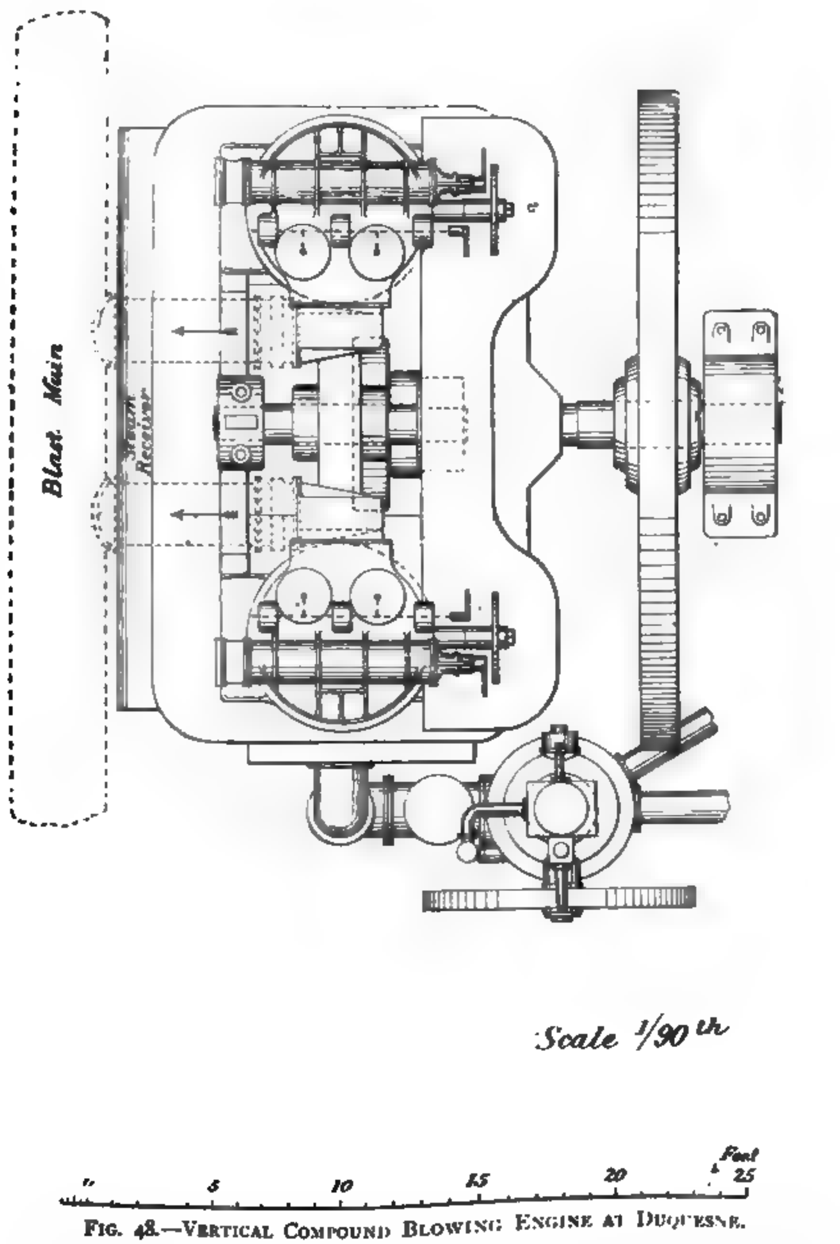


FIG. 48.—VERTICAL COMPOUND BLOWING ENGINE AT DUQUESNE.

including the works of the Carnegie Steel Company, and of Messrs. Jones & Laughlins, at Pittsburg. It is directly connected to the rolling mill, gearing being dispensed with, but great accuracy of construction

is required to prevent heating of the inner crank wrist. This, and the exceptionally heavy weights required, make the engine expensive.

Fig. 59 illustrates a compound condensing engine, and Fig. 60 a cross-compound rope-driven Corliss engine, both of which are well known

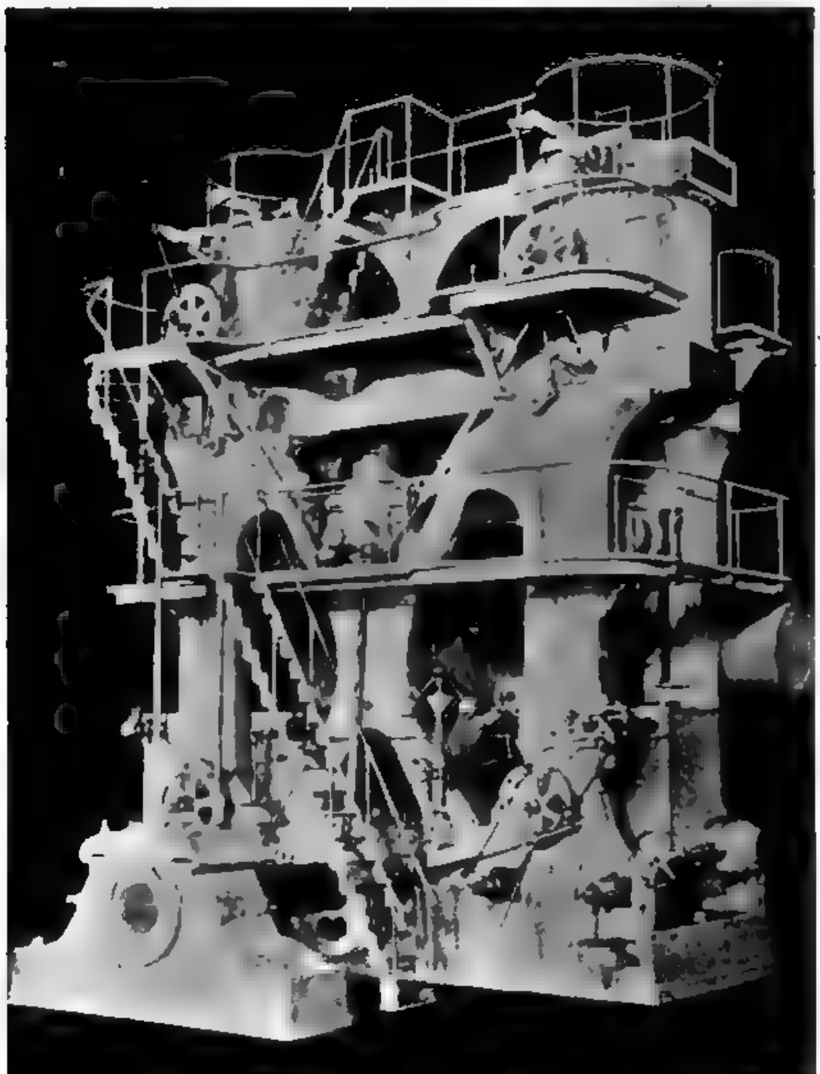


FIG. 49. ELEVATION OF VERTICAL COMPOUND BLOWING ENGINE AT DUQUESNE WORKS.

in American power plants. In Fig. 61 is shown a compound condensing engine, in which the low-pressure cylinder is placed in front of the high-pressure one, and is bolted to the rear end of the bed-plate, which forms the front head of the cylinder. Other features of this engine are

that the independent air pump is compound, and the high-pressure cylinder is connected to the low-pressure by distance pieces.

Two other types may be named that of the compound condensing

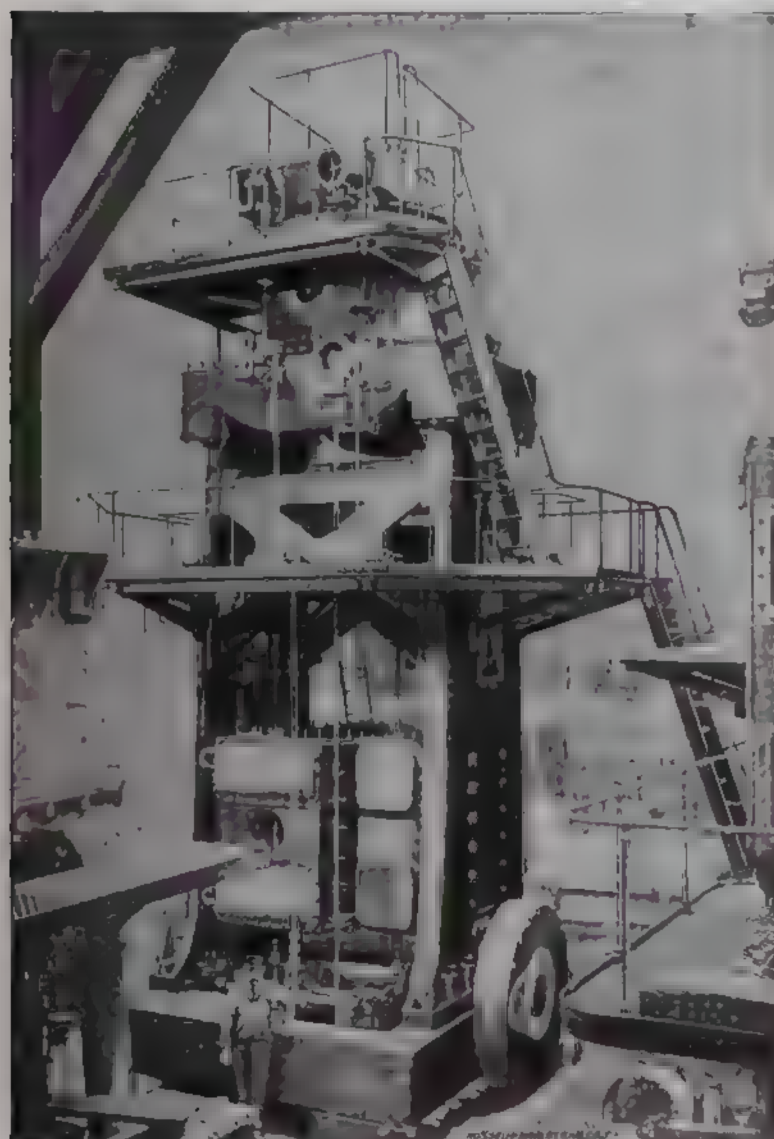


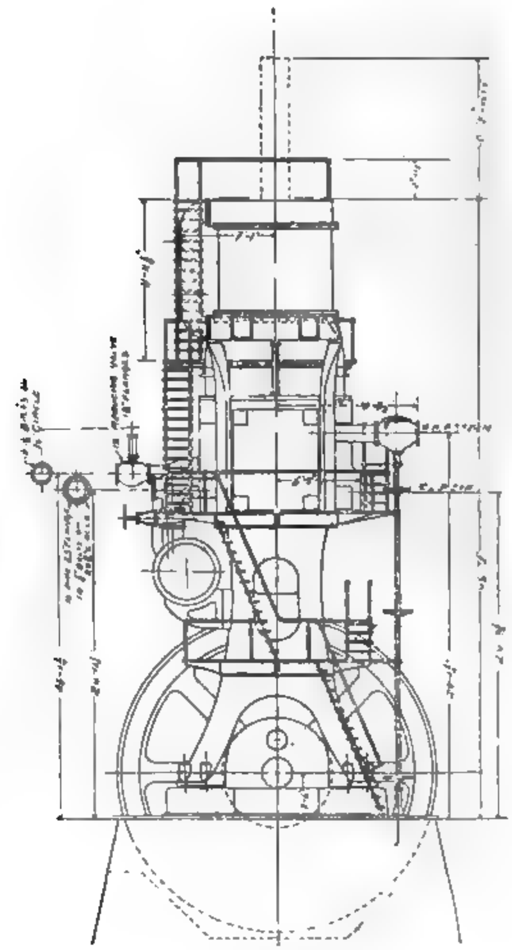
FIG. 50.—SOUTHWARK COMPOUND CONDENSING ENGINE.

Bessemer blowing engine, illustrated in Fig. 62, in transverse and longitudinal sections, and that of the vertical piston-valve engine shown in Fig 63, the latter of which is built for situations where space is limited, and

is recommended by Messrs. Mackintosh, Hemphill & Company for driving heavy bloom shears, where the engine is required to be close to that tool.

Locomotive Engines, Electrical Plant, &c.

From the Report of the Inter-State Commerce Commission for



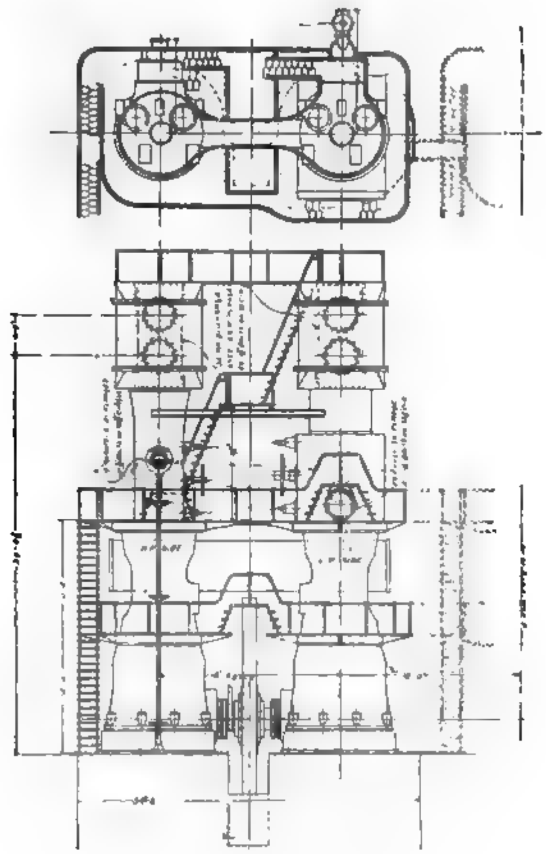
SIDE VIEW.
FIG. 51.—VERTICAL CROSS COMPOUND BLAST FURNACE BLOWING ENGINE "STEEPLE TYPE," BY THE ALLIS-CHALMERS CO.

1900, with a copy of which I have been favoured by the president of that tribunal, I find that the total number of locomotives in service in the United States in that year was 37,663, and that this is an increase of 2,171 on the number in 1894, while the increase in 1900 alone over 1899 was not less than 960. Of the total for 1900, 21,596 were freight,

9,863 were passenger, and 5,621 were switching locomotives, while 583 were unclassified.

It may lend completeness to this record if I add that at the same date there were 1,450,838 cars of all kinds in service on American railways, including 1,365,531 freight, 34,713 passenger, and 50,594 other cars, described as "Company's service." In 1900 alone the increase of cars over 1899 was 74,922.

Much has been written as to the general characteristics and com



FRONT VIEW.
FIG. 52.—VERTICAL CROSS COMPOUND BLAST FURNACE BLOWING ENGINE "STEEPLE TYPE," BY THE ALLIS-CHALMERS CO.

parative merits of the typical American locomotive. It has been compared and contrasted with its British rival again and again, and I am not sure that any good purpose would be served if I were to attempt to carry the matter further.

A number of the leading American railroads have their own locomotive works. The Pennsylvania Railroad carries on at Altoona what is perhaps the finest establishment of its kind in the world, and this organisation alone had, "available for service on the lines of its

system," at the end of 1900, 4,199 locomotives, of which 2,273 were designed and used for freight purposes. Others, and the majority

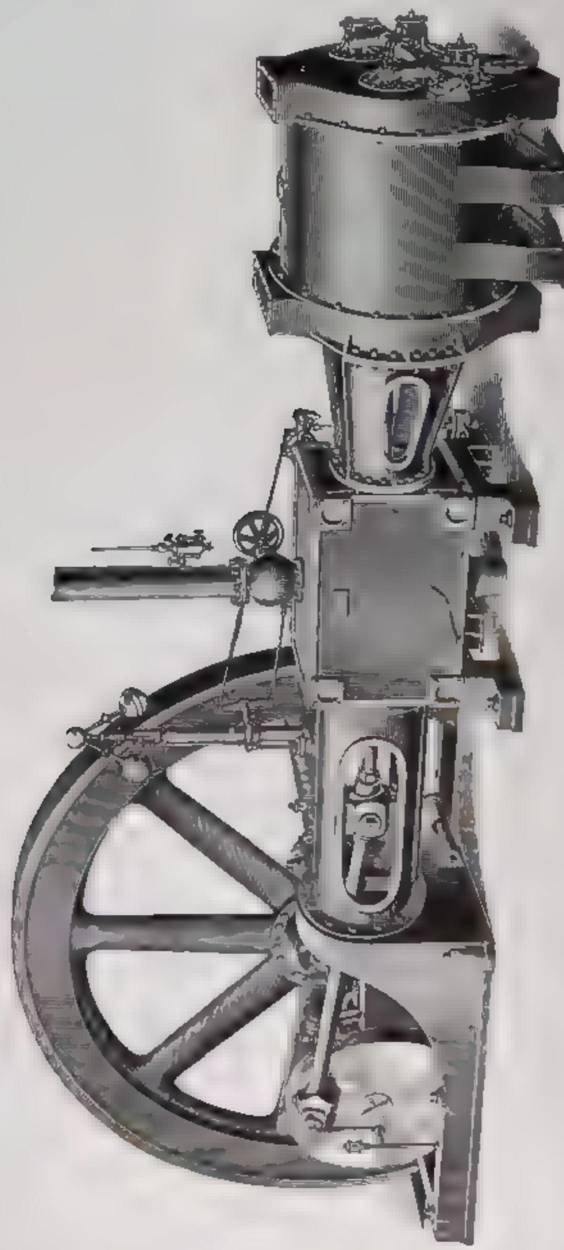


FIG. 53. HORIZONTAL SINGLE BLOWING ENGINE, BY THE ALLIS-CHALMERS CO.

of the American railroads, buy their locomotives from the principal private makers, such as the Baldwin and the Pittsburg Locomotive Works.

Mr. Vauclain handed to me, at the works of the Baldwin Company, an interesting history of that enterprise from 1831 to 1897, from which I find that it had built its fifteenth thousandth locomotive in 1896, since which time, however, the annual output has been

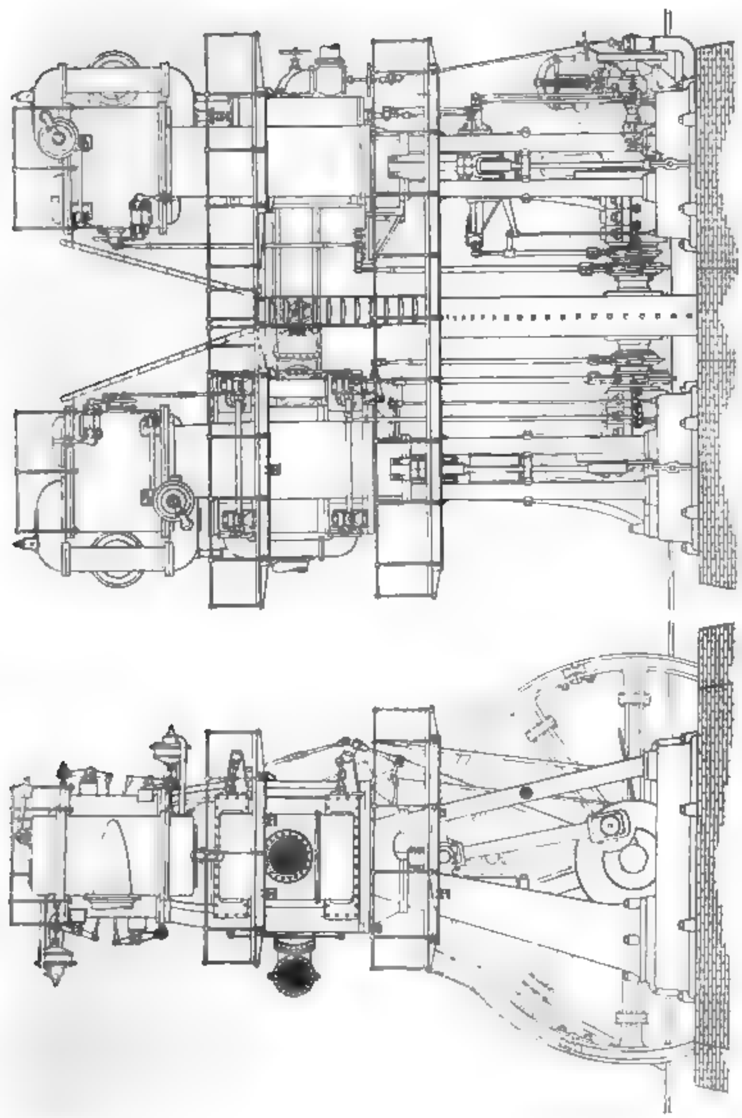


FIG. 54.—"BUCKEYE" BLOWING ENGINE.

almost doubled, and the present capacity of the works is stated to be more than 1,200 locomotives per annum, or more than three for every working day. Since 1896, moreover, the number of hands employed at the Baldwin Works has advanced from 5,100 to about 10,200. These figures are given because they illustrate the

general character of the phenomenal advances made of late years in the locomotive industry generally.

These advances are, of course, not entirely founded on home

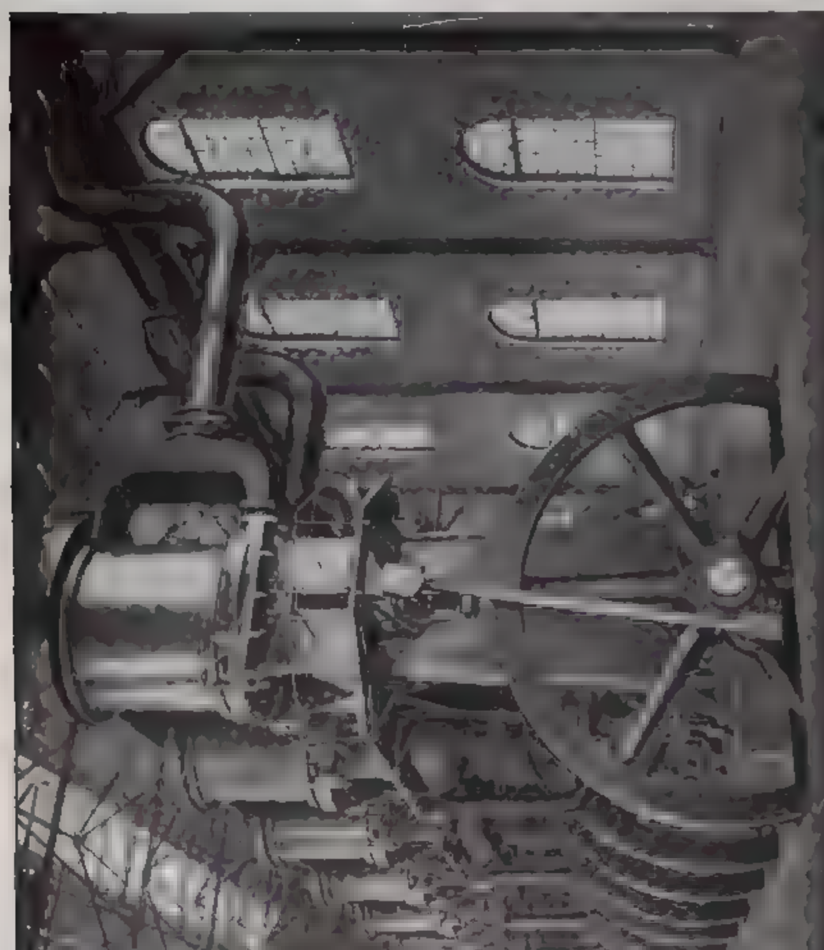


FIG. 55.—BATTERY OF SOUTHWARK BLOWING ENGINES.

requirements, although, as we have seen, those requirements have enormously increased. The locomotives built in the United States by the Baldwin and other companies are now exported to most of the principal countries of the world, in competition with those of Great

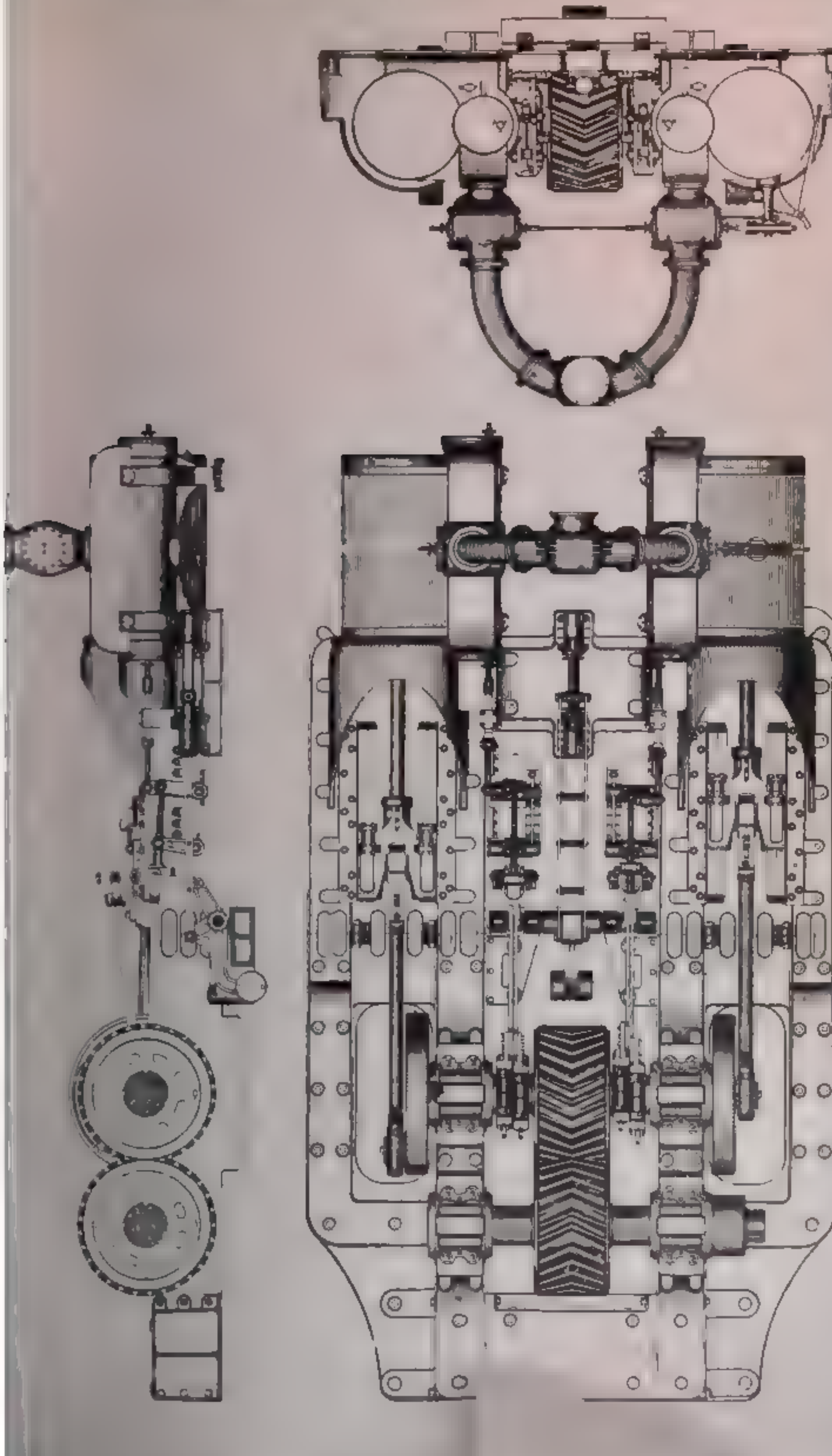


Fig. 56.—Evans-geared Reversing Engine.

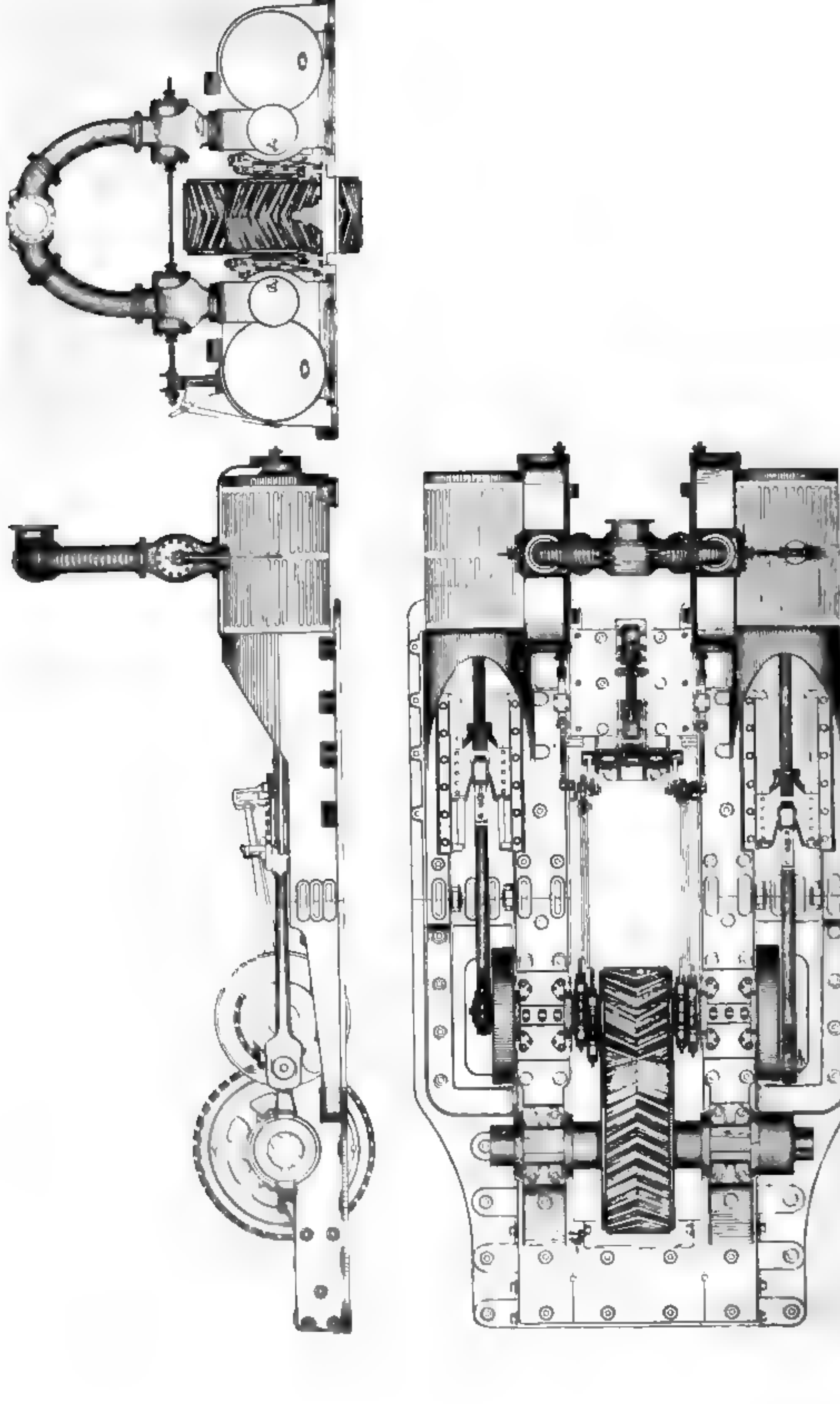


FIG. 57.—DIFFERENTIALLY-GEARED REVERSING ENGINE

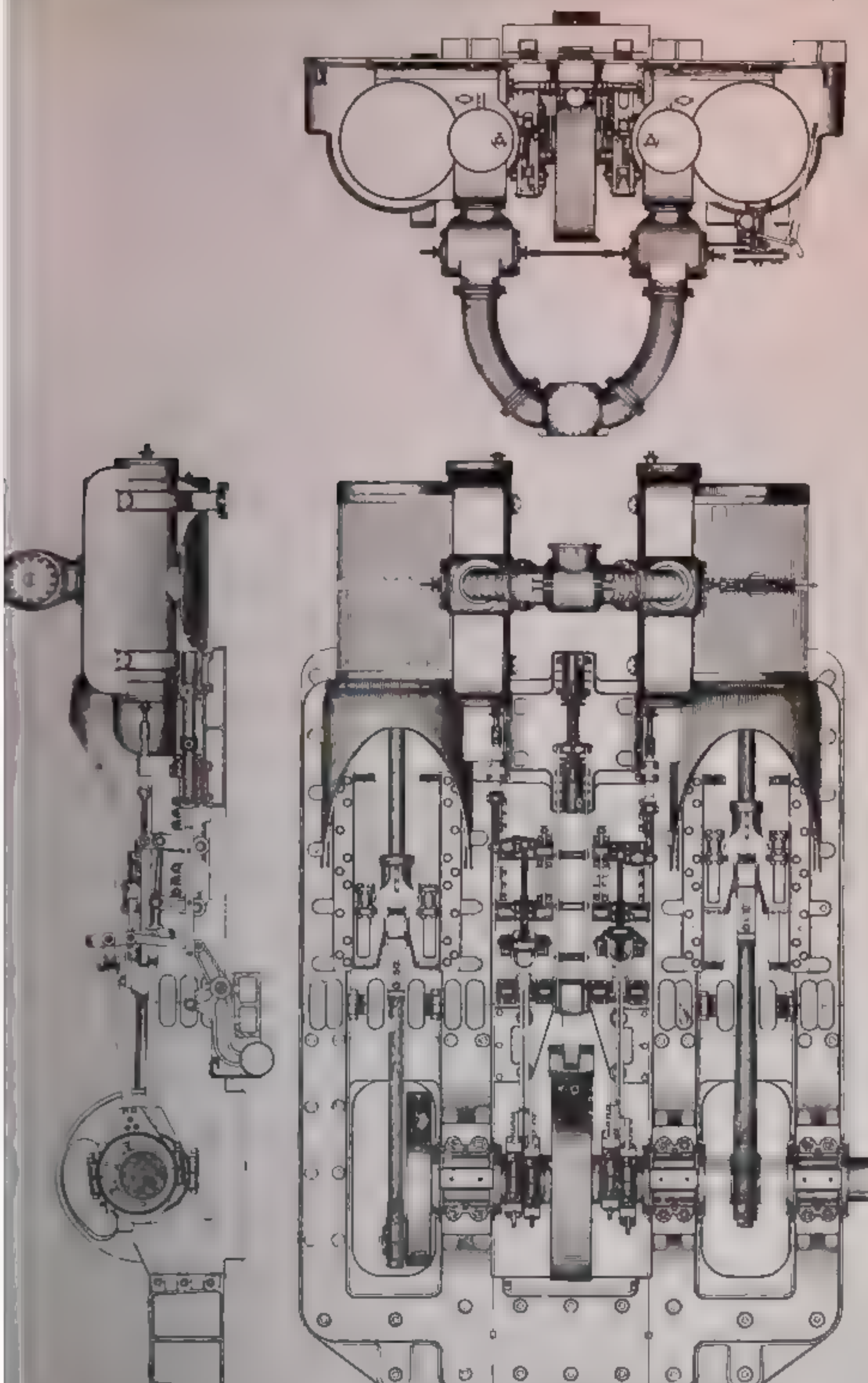


FIG. 58.—DIRECT-COUPLED REVERSING ENGINE.

Britain, which, however, still retains the largest foreign business under this head.

British locomotive engineers will probably continue to hold their own so long as opinions differ as to whether a high finish or a rough is the more desirable; whether steel plates or copper are to be preferred for fire-boxes; whether the centre of gravity should be higher or lower;

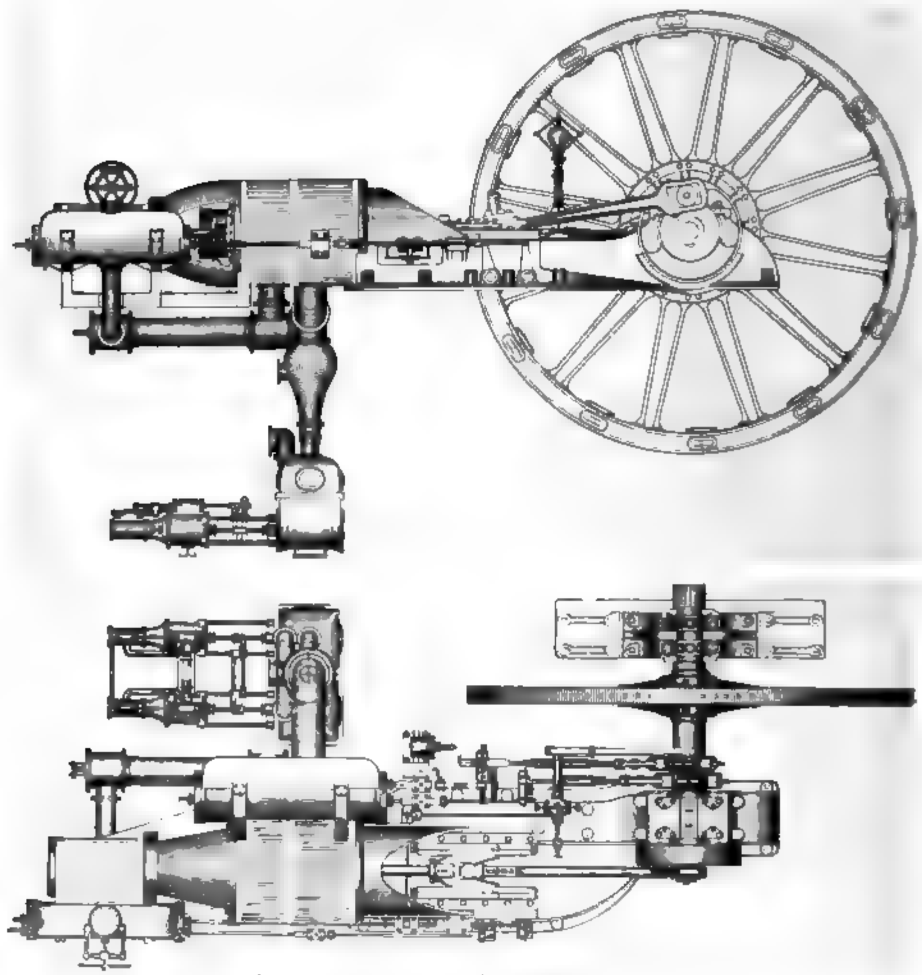


FIG. 59.—COMPOUND CONDENSING ENGINE.

whether the bogie truck is an essential; whether outside cylinders and straight or crank axles yield the most satisfactory results; and whether the bar frame is likely to hold the field. But while these questions are likely to continue to vex the souls of locomotive buyers and users, I should, I think, point out that recent testimony from India, Japan, Egypt and Burmah has almost uniformly been in favour of the British locomotive, although the American is usually the cheaper machine, at least nominally.

Apart from the importance which always attaches to production on a large scale, and which must favour the locomotive maker, as well as any other manufacturing engineer, the locomotive industry of the United States is one of the many customers of the iron industry of that country who creates demands to which the British iron trade is relatively a stranger. Mr. Vauclain informed me that in the Baldwin

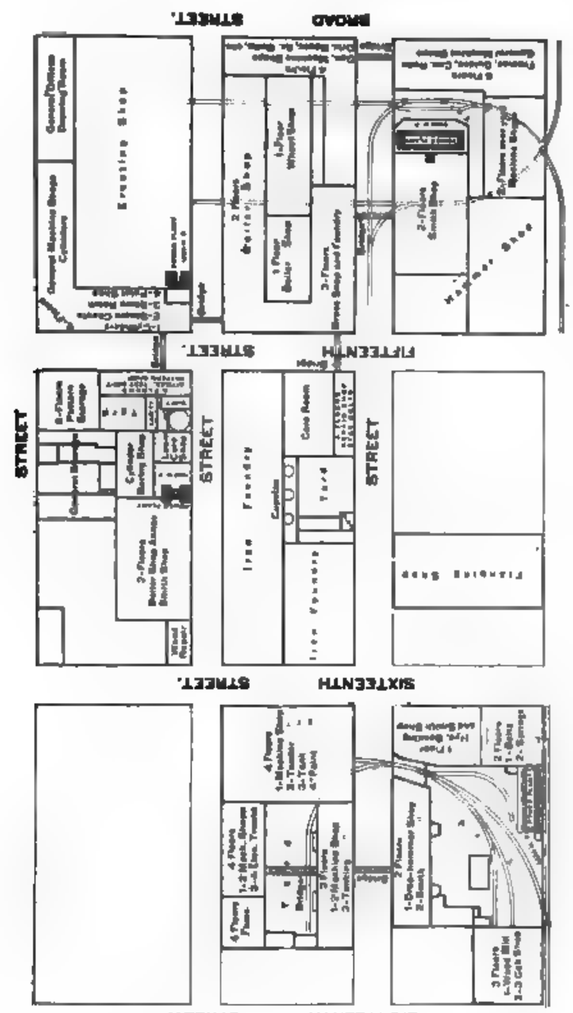


FIG. 59A.—GROUND PLAN OF THE BALDWIN LOCOMOTIVE WORKS IN PHILADELPHIA.

Works alone the consumption of iron and steel exceeded 3,000 tons, and of other materials approximately 900 tons per week. This is apart from the demand due to the extensive plant employed, which embraces 7,000-h.p. in engines, 1,850-h.p. in dynamos, and 3,500-h.p. in electric motors. In view of the international reputation of this great establishment, I have reproduced herewith a ground plan showing the location of the principal shops, etc. (Fig. 59A).

In another section the development of electrical plant and methods is dealt with, so that I do not propose to consider the subject further here, but the vast extent of the application of this form of power is sufficiently indicated by the figures given in the last paragraph as to its use in the Baldwin Locomotive Works alone.

General Machinery and Machine Tools.

American workshops generally bear ample testimony to the vast resources of American mechanical engineers in the design and manufacture

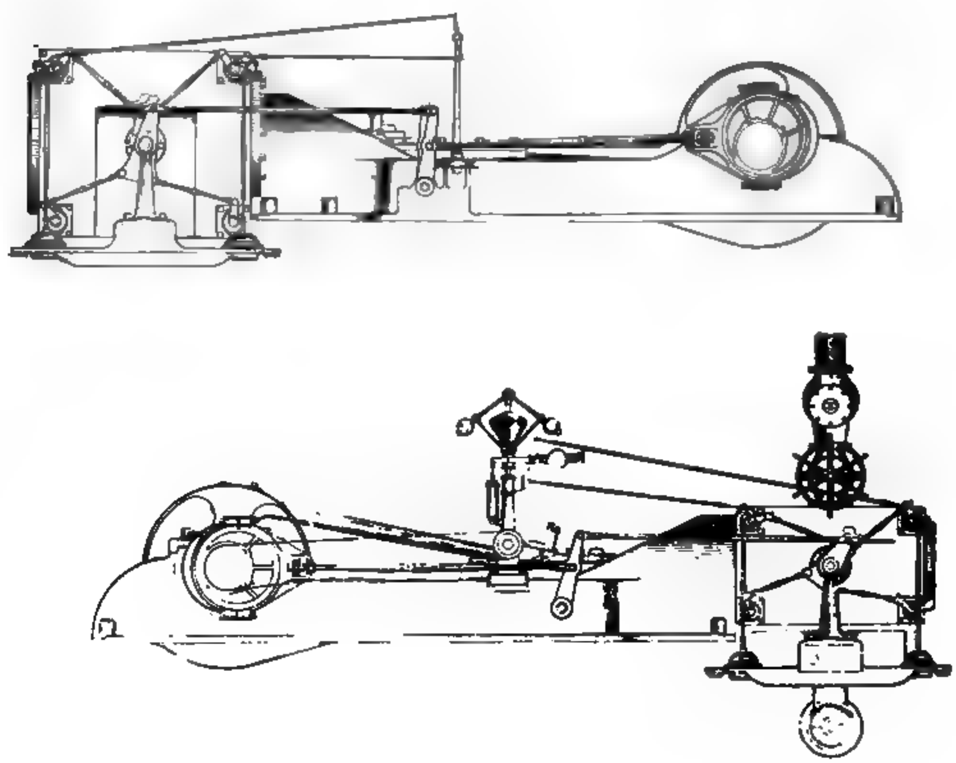


Fig. 60.—Cross Compound Rope-Driven Corliss Engine.

of machine tools of all kinds. The first opportunity that was afforded of displaying their capabilities in this direction was that given at the Chicago Exhibition of 1893, but, short as the interval is that has since elapsed, it may almost be affirmed that in some not unimportant particulars the machine-tool industry of the United States was then little more than an infant. It is certain that the leading manufacturing engineers have since that year made vast strides in the design and construction of tools suited to the working of metals, from those used in cycle construction up to the heaviest employed in the forging of guns and armour plates.

Some of the principal machine tools used in American steel works

are elsewhere described and illustrated in this volume. A few others may here be named.

In planing machines, one of the most notable tools I got details of was one designed to plane 25 ft. in length, and measuring 144 in. by 120 in., designed for the heaviest work in armour plates and other

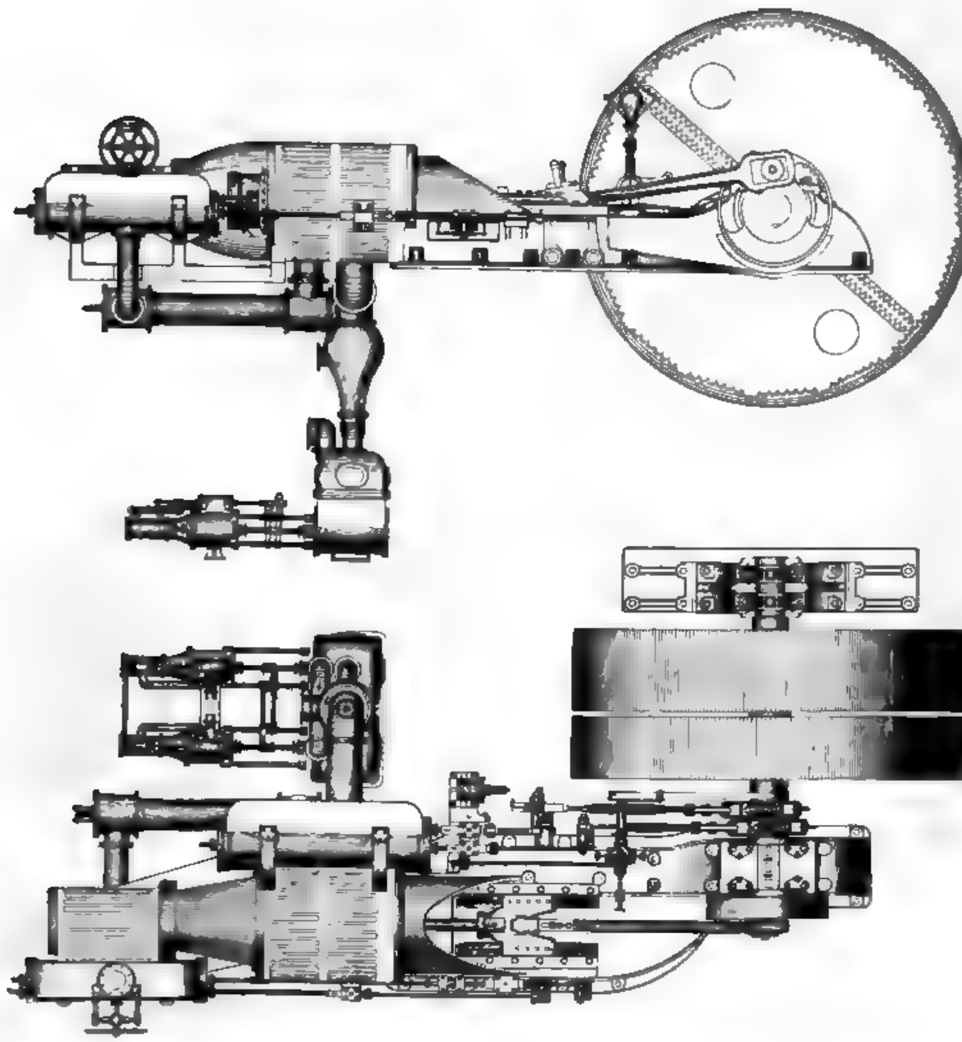


FIG. 61.—COMPOUND CONDENSING ENGINE.

forgings. It is provided with two saddles, 45 in. long on the cross rail, which is 42 in. deep. The swivel tool slides on the saddles are 6 ft. long by 20 in. wide, and have a stroke of 3 ft., while the tool apron and clamps are proportioned for a cutter bar 6 in. square. Each saddle has its own feed screw and rod actuated by an independent feed motion at the end of the cross rail, which is 22 ft. 8 in. long. Each has its own

electric motor for rapid traverse, while another motor is employed to raise and lower the cross rail. The housings, or uprights of box form, are 30 in. wide on the face, 8 ft. 6 in. deep, and each is provided with a slide-rest having 30-in. stroke and carrying a tool apron adapted for 4-in. square cutter bar. The machine is built by W. Sellers & Co. (Fig. 64).

Fig. 65 shows Crosgrove's patent beam straightening and bending machine, as made by Mackintosh, Hemphill & Company, in which the exact amount of bending or straightening desired is effected by projecting the ram more or less from the operating shaft by thrusting

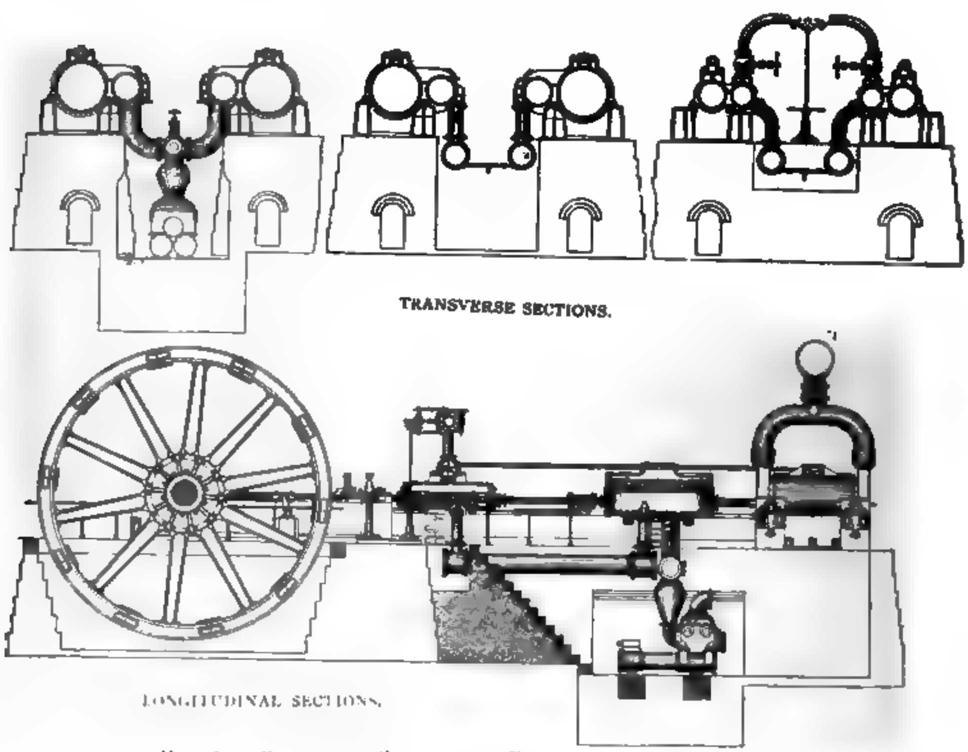


FIG. 62.—COMPOUND CONDENSING BESSEMER BLOWING ENGINE.

in a wedge, and Fig. 66 shows a heavy shear, made by the same firm, for cutting large sections of hot steel, which is to be found at most of the leading steel works in the country. It is found especially useful as an adjunct to blooming mills, where only approximately square heavy blooms are cut to short lengths. The shear illustrated was built to cut 10 by 10 in. sections of hot steel.

One of the most notable features of American rolling mills is the ingenuity and skill displayed in designing appliances for the automatic movement of ingots, blooms, billets, or other forms being operated on in their passage from one stage of reduction to another. Many different appliances and systems are employed for this purpose. Live rollers, skid gear, and tilting arrangements of various kinds are all well known

and are generally made use of. Figs. 67 and 68 illustrate an ingot manipulator which is of ingenious design and is in extensive use throughout American steel works.

In speaking of rails and plate mills, some leading examples have been illustrated in previous chapters. The blooming mill at the Cambria Steel Works is one that may also be mentioned. It is one of the most notable in the country.

The characteristics of the typical American engines are numerous, but in nothing probably are they more so than in their valves and

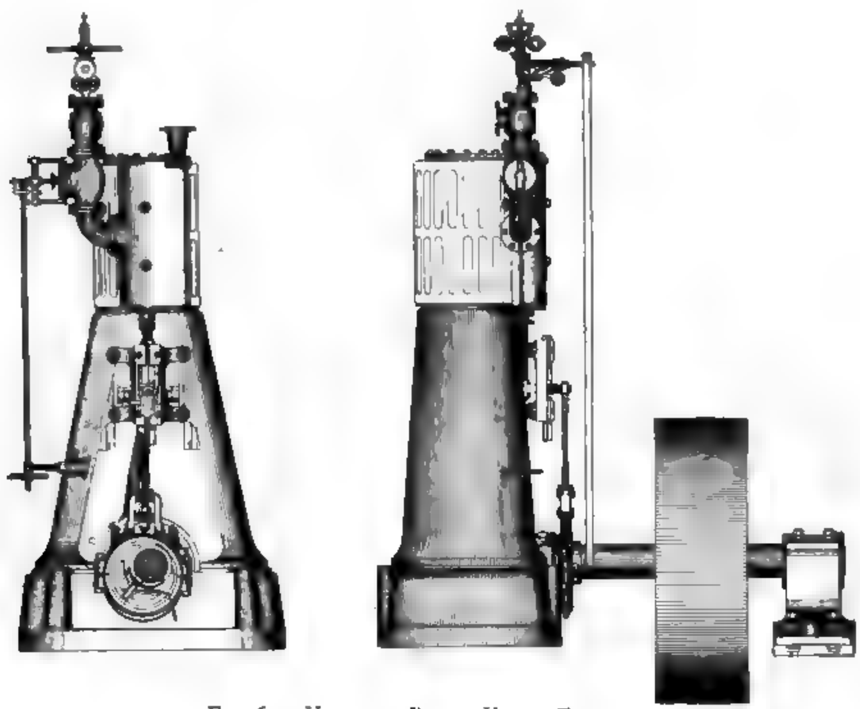


FIG. 63.—VERTICAL PISTON-VALVE ENGINE.

valve-motions. Some of the more distinctive of these are but little known or used in Europe.

Tools for Special Uses.

Mr. Newton, of the Newton Machine Company, of Philadelphia, called my attention to several features that distinguish American from British machine-tool practice. That firm, he stated, made portable machines up to 50,000 lbs. They attach electric motors to such tools in every case. Planing machines are very little used, their place being taken by a rotating head, with a surfacing end up to 30 in. Rail-ending machines were not used until six or seven years ago. These machines have to get through a great deal of work at such a plant as that at South Chicago, where seven rails per minute are rolled.

The American mechanical engineer probably does more than his

British *confrère* in designing and building tools that are adapted for special uses, although, in this connection, one must not forget the splendid work done by British engineers on extraordinary occasions, such, for example, as the machine-tool plant designed and built by Sir Thomas Arrol for the Forth Bridge. Mr. Newton gave me particulars of a number of very successful essays at more effective machine-tool work undertaken by his own firm.

A typical case was that of a five-spindle boring machine, which, with only one man to operate it, took the place of five lathes and five men, who, moreover, had some helpers.

Among recent features of the machine-tool practice of his firm, Mr. Newton called my attention to the machines that they have recently introduced for the purpose of cutting large rolling mill gears, which, as is well known, cannot conveniently be cast. These machines take a

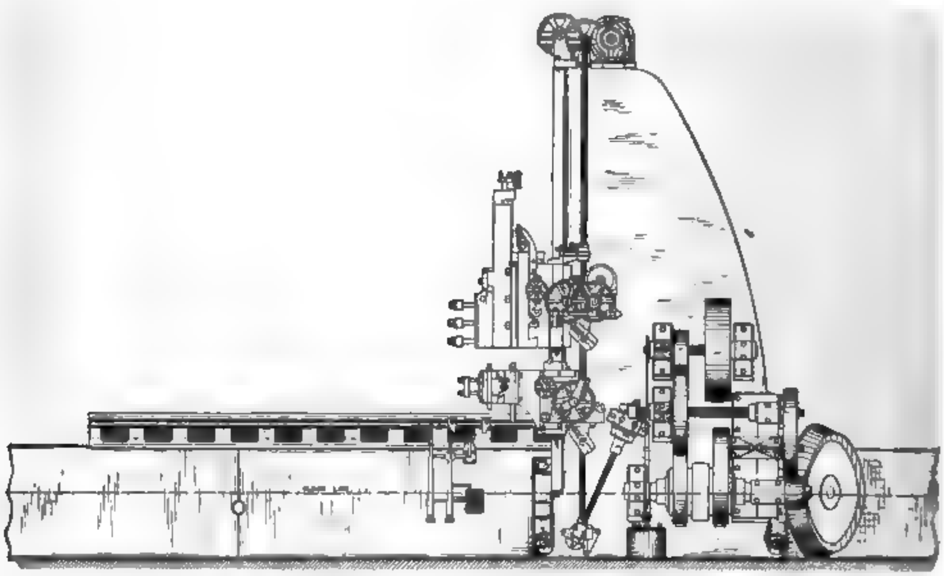


FIG. 64. PLANING MACHINE.

5-ft. space, and can be made to take any diameter, but one just completed took a diameter of 30 ft., with an 8-in. pitch. In rolling mill practice, pinions are being made with a 5-ft. face.

Another case calling for the design of special tools was that of the enormous generators provided for the Manhattan Elevated Railroad. Not having at command any tools suited to machine these generators, the engineers called on the Newton Company to design special tools for the purpose, which they did.

Mr. Newton seemed to hold the opinion that British machine-tool practice was behind that of the United States, and as cases illustrative of this view, he referred to the quicker-running cold saws used in the United States for treating girder rails, beams, and channels, whereby the time expended on the operation is greatly reduced, compared with the British system of slower motion. The same remark applies to

armour machine tools, one such tool, supplied by the Newton Company, planing 36 in. per hour on a Krupp 6-in. plate. All this, of course, is only another way of saying that which has been said almost *ad nauseam* of late years, that in the United States the machine tools are differently speeded to those used in British practice.

Wages in Engineering Shops.

When I was in Philadelphia I had a long interview with Mr. William Sellers, head of the large machine-tool firm of W. Sellers & Company (Incorporated), who gave me a good deal of information as to the conditions of work and wages in that city, and instructed one

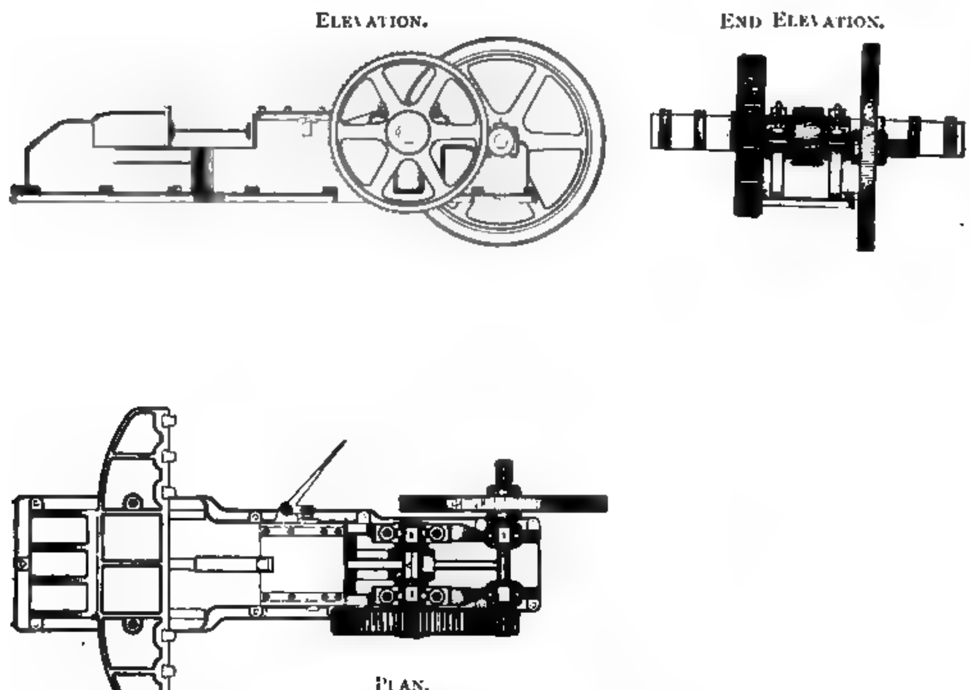


FIG. 65.—CROSGROVE'S PATENT BEAM STRAIGHTENING AND BENDING MACHINE.

of his officials to have copied for me, from a wages book, a statement of the rates paid to different classes of workmen. This statement I have published in the Appendix, but the substance of it, expressed in terms of dollars per week, is as follows :—

Category	Dols.	Dols.	Category	Dols.
Fitter	13·57 to	18·84	Labourer	15·42
Electrician ...	12·37		Apprentice	7·87
Carpenter ...	12·26		Helper	8·55
Toolgrinder ...	12·75			

Speaking of lathe work, Mr. William Sellers said to me: "We don't think it is good policy to have more than one man on a turning lathe, but there is a class of work that allows of two lathes being given

to one man." The lathes, however, are generally more high-speeded than in Britain, and the day's work is longer, being usually 10 hours. Mr. Sellers gave me the average wages in his large establishment as 2 dols. 60 cents (10s. 10d.) for tool work, and about 1 dol. 20 cents (5s.)

ELEVATION.

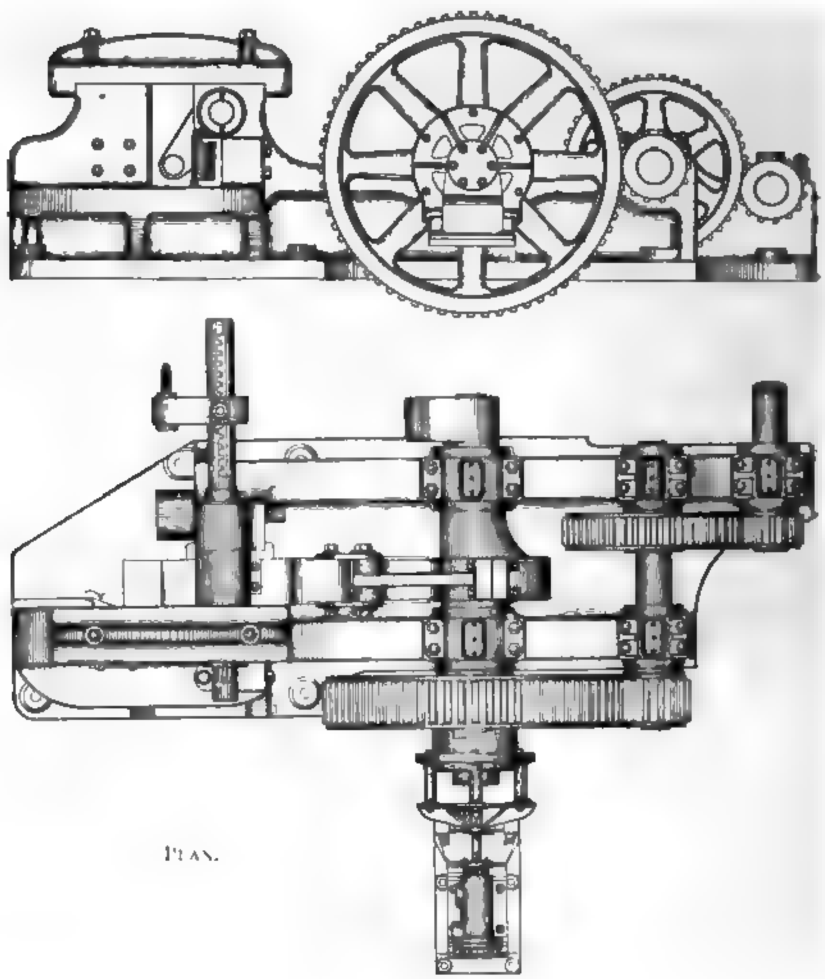


FIG. 66.—STEAM-DRIVEN HORIZONTAL HOT BLOOM SHEAR.

for ordinary unskilled labour per day. There are lathe men, however, who draw at these works as much as 3½ dols. (14s. 6½d.) per day.

Economy of Cast-Iron Tools.

At the works of William Sellers & Company I was shown an interesting new departure, in the application of tools made of hardened cast iron, so as to take a cutting edge, at a cost of about 16 cents per lb., in the place of "Mushet steel" tools, at 35 cents per lb. I was informed that the men prefer the use of the cast iron, both because the

metal is harder, and because if the tool is injured in any way, they do not lose time in going through necessary but troublesome forms to procure another, as they would do with the more costly steel. The worn-out cast-iron tools are sent back to the foundry to be remelted.

In the same shops I saw in operation a machine for sharpening tools, which, as I was informed, can do all the tools used by about

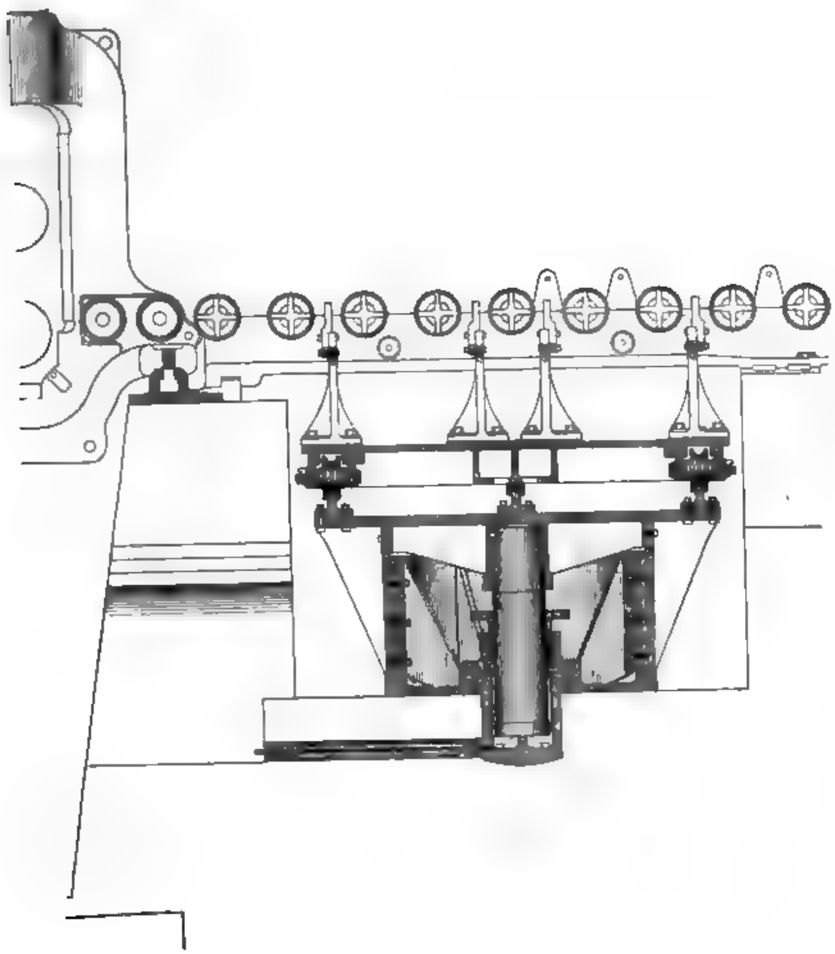


FIG. 67.—INGOT MANIPULATOR.

700 hands, forming and grinding them at the rate of about 60 per hour. I also noticed two men working auto-gear cutters, attending to several machines at one time.

Heavy Machine Tools.

Some 15 or 20 years ago, in the United States, the manufacture of very heavy machine tools had hardly been undertaken to any extent

worth speaking of. Many of the principal tools of this description were imported from Great Britain. It is not more than 10 years since the Carnegie Company imported their heaviest armour-planing machines

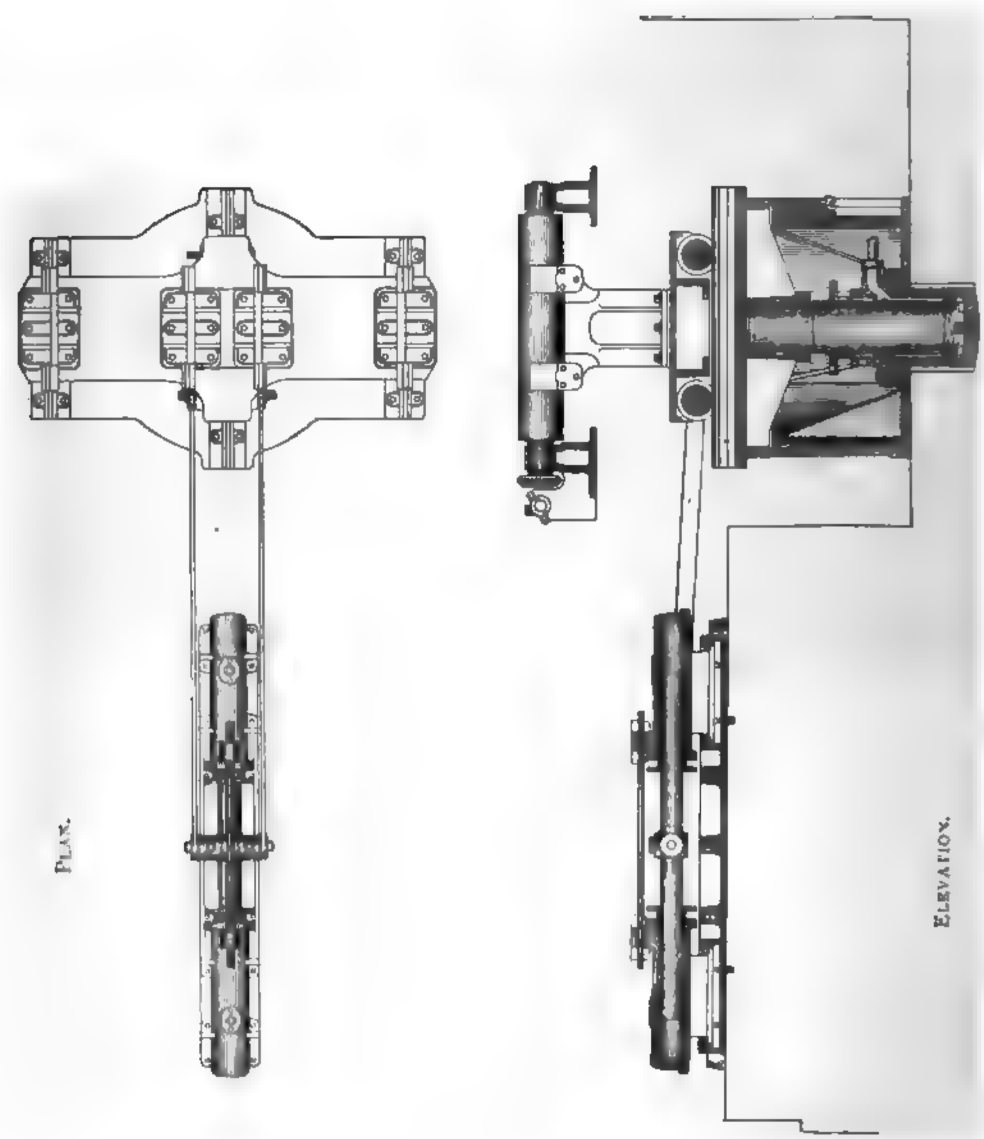


Fig. 68.—Details of Ingot Manipulator for Reversing Blooming Mills

from Scotland. The British Isles were *par excellence* the home of the heavy machine-tool industry.

This condition is now greatly changed. There are many firms in the United States that undertake the production of the very heaviest class of machine tools. Such tools have been imported into British

workshops, including several armour-planing machines of exceptional size, which have been adopted at one of the leading Sheffield works. Several firms in America now undertake the production of such tools. Mr. William Sellers gave me some particulars of an armour-plate planer, which his firm had designed for and supplied to the Midvale Company, and which is in some respects remarkable and typical. It takes a cut of 100,000 lbs., or four cuts of 25,000 lbs. each, runs back at a high rate of speed, has a slow-speed undercut, and is 12 ft. wide by 10 ft. high.

Pneumatic Tools.

One of the prominent features of the machine shops of the United States is the large use of pneumatic tools. These tools work at 80 to 100 lbs. pressure. It is, perhaps, unnecessary that I should go into details, as the types of air-driven tools in use in the United States have been applied in British workshops for many years. Portable pneumatic tools are, however, a more distinctive American invention.*

One of these systems, known as the Caskey riveter, at a works in Philadelphia, drives 4,800 rivets per day with six men—one to operate the machine, two to bolt up the work, and three to heat the rivets.

The Invention of Improved Tools.

Two other features of the mechanical engineering workshops of the United States claim attention—the first, the widespread and increasing use of *special* machinery; the second, the persistent efforts of both employers and employed to invent something that will do better work than the machine which it is intended or expected thus to replace.

It has been said that an American mechanic not only invents wonderful labour-saving machines, but he also invents machinery to build the machines. I recently came across a few reflections on this subject which express so exactly the true situation that I herewith reproduce them *in extenso*:—

> "It is one of the peculiarities of American mechanics that in the evolution of an idea a device of totally new form may be found an essential part. When perfected perhaps no standard machine or process will produce it to the satisfaction of the inventor. It may sometimes happen that an invention cannot be utilised because it requires a part or parts too difficult or expensive to make for the purpose. Ordinarily, however, the inventor is not vanquished by such an obstacle, but proceeds further, and originates a method by which his purpose is accomplished. Much is being done in this way in small shops, in which the use of special machines would hardly be expected. It can be said, however, that few metal-working factories of any pretensions can be found in which the machine shop is not employed to some extent on special machines for their own use, and which are preferably built on the premises. The experimental department involves considerable expense, and much money may at times be sunk in it without an adequate return, but it is found necessary for the

* While I was in the United States, it was announced that one of the largest shipbuilding firms in Scotland had given to one of the largest pneumatic tool companies an order for 1,525 pneumatic tools, as follows:—275 Boyer long-stroke hammers, 350 No. 1 Boyer chipping and caulking hammers, 400 No. 2 Boyer chipping and caulking hammers, 25 No. 000 Boyer extension riveters, 25 No. 000 Boyer yoke riveters, 25 1¾ in. by 6 in. Boyer yoke riveters, 150 No. 2 Boyer drills, 250 No. 3 Boyer drills 25 No. 4 Chicago breast drills.

vitality of the enterprise. The manufacturers who do not experiment, or who are not on the alert to find something better than they are using or producing, are in danger of being left in the rear."

Compressed Air.

Another notable feature of mechanical workshops and foundries is the extensive use of compressed air as a means of power transmission. To a large extent this medium of power is a formidable rival to electricity. I have been informed of one engine works where there are about 30 cranes operated by compressed air, and of another where a new form of shear, actuated by compressed air, enables two boys to cut off 700 to 800 locomotive boiler stay bolts per day of ten hours, which is many times the output got by the hammer and chisel formerly employed. Compressed air is also largely employed in foundry practice, in drawing patterns, closing flasks, etc.

Electricity is now almost universally employed in American engineering workshops, and it is the usual practice to give each machine its own independent motor. For some purposes, however, manufacturers often prefer to employ compressed air.

Effect of Cheaper and Better Steel.

The capacity of American machinery manufacturers to compete in outside markets has been much facilitated of late years by the command of a cheaper and more suitable quality of steel. This circumstance recently led some manufacturers to place contracts for soft steel to take the place of the rolled iron sections which they had previously been using. Soft steel having a tensile strength of 60,000 lbs. to the square inch, as compared with 45,000 to 50,000 lbs. for ordinary bar iron, the greater toughness of the steel has enabled manufacturers to reduce the thickness of the parts thus made, and permitted them to build lighter machines than when iron was used. This, however, has necessitated a change in the machinery and methods throughout the shops, in new dimensions of dies, etc.

A Story with a Moral.

For a number of years past the aim of the American manufacturing engineer and inventor has been to make machinery as far as possible automatic. In other words, every effort is made to reduce the necessary dependence of employers on skilled and highly-paid workmen, as such. This end is also facilitated by the American practice of almost infinite duplications of machine products. A short story recently published shows the tendency of this movement. In a well-known engineering shop a large planer was installed. It was a much bigger tool than any other in the shop, and represented quite a change in the equipment. A competent machinist was given charge of the planer, and, after running it for a month, he asked for an advance in wages, claiming that he should receive higher pay on account of its greater size and the heavier work turned out by it. He was given another job, and a second man was assigned to the machine. In a short time he made

the same demand, and a third man was put in charge of the planer, with whom the manager had a like experience. Growing tired of this result of putting good mechanics in charge of what he considered a simple tool, the manager asked the foreman of a labouring gang to point out some man from among them of fair intelligence and a little education. Such a man was found, and the manager asked him: "Can you read and write?" "Yes." "Have you ever worked in a machine shop or at any kind of a machine?" "No." This being deemed a satisfactory condition precedent, the man was taken into the machine shop, and put in charge of the planer, and after a course of instruction extending over two or three weeks he was able to manage the tool without supervision, and was regularly employed to operate it from that time. The selection of this man was designed as, and proved to be, a lesson to all the men.

Some Differences of Importance.

A recent writer has declared the essential difference between European and American engineering workshop practice to be, that while the Americans rely mainly on labour-saving machinery, under which a high percentage of low-paid labour is possible, and not on a large number of average workers, the European machine shop maintains a much larger number of skilled workers at a high rate of wages, and do not equally rely on labour-saving machinery and methods.

In a number of the leading machine shops of the United States, the practice now adopted, with a view to keeping down the wages bill, is to rough-mill large surfaces on heavy milling machines, and then to finish these surfaces accurately with a light cut on the planing machine. It has been claimed that under this system 75 per cent. of the work is done by unskilled labour,* one man running from two to four machines, while the wages of the skilled mechanic, who is mainly concerned in seeing that the tools are in good working order, are distributed over a group.

It has been said that a characteristic peculiar to American makers of machinery is the constant interchange of information, even between sharp competitors. It has also been said that "shops are usually open to all visitors, and little of that narrow spirit too often shown by European manufacturers exists among American machine tool-makers." Both of these conditions came under the range of my own observation again and again. The former is largely due to the fact that American works specialise a good deal more than those of Europe, so that they have a more limited area within which to confine and collect their information as to one another's doings. The second is a function of the prevalent thirst for new ideas, which is only to be quenched by interchange of experience, and the prominent results of which are the ready adoption of the improvements in methods of manufacture.

Arrangement and Characteristics of American Machine Shops.

While some of the better known machine shops of the United States are not by any means modern in the American acceptation of the term,

* H. F. L. Orcutt in the *Engineering Magazine* for February, 1899, p. 706.

others are probably at least equal to anything to be found in the Old World in the perfection and completeness of their equipment. In this latter category special notice is merited by the new works of the Mesta Machine Company, located near to the Homestead Steel Works, in the vicinity of Pittsburg. The foundry department of this plant, which is illustrated herewith (Fig. 69), is especially notable.

This plant was only constructed in 1899, and it embraces the most modern equipment in the United States for the manufacture of heavy Corliss engines and rolling-mill machinery, while it is claimed to be the largest plant in the world engaged in building rolls and rolling mills. The Mesta Company have facilities for making sand, chilled, and steel rolls, their equipment embracing two 15-ton, two 18-ton, and two 30-ton air furnaces. The foundry department is 820 ft. by 125 ft., and is equipped with nine overhead travelling cranes, ranging in capacity from 10 to 50 tons. The air furnaces in the roll foundry are charged by an electric travelling crane, direct from the metal yard. In the green and dry sand foundry, which is 210 ft. by 280 ft., the equipment embraces 72-in. and 84-in. cupolas, a number of overhead travelling cranes, ranging in capacity from 10 to 50 tons, drying ovens, core ovens, and a brick-moulding department for casting cylinders, etc. A special shop for the moulding of gears is placed between the steel foundries, so that the moulds may with equal facility be filled with iron or steel. The foundry buildings are placed parallel to and directly opposite the machine, chipping and finishing shops, instead of tandem, and the railway tracks are so arranged that the raw material passes through the departments that deal with it in consecutive order, without entering any other.

A ground plan of the Mesta Machine Works is shown on page 233.

The steel foundry at the Mesta Machine Company's Works is one of the best equipped, as it is also one of the latest in the country. It is 280 ft. by 125 ft., and has one 25-ton and one 30-ton acid open-hearth steel furnaces, controlled by four overhead travelling cranes. One annealing oven is of the largest size, and is fed with natural gas; it anneals castings up to 50,000 lbs. Steel is largely employed in casting cranks, rolls, housings, engine shafts, etc. A building adjacent to the steel foundry is equipped with cold saws, and other plant for cleaning the castings as received from the foundry.

Works and Operations of Mackintosh, Hemphill & Company.

While in Pittsburg it occurred to me as desirable to learn something of the conditions under which such works as the Duquesne and Homestead were furnished with their mills and other plant, and I therefore asked for and obtained permission to see over the works of Mackintosh, Hemphill & Company, which are located within the city boundaries, have been carried on since the year 1859, and have probably supplied a larger percentage of the heavy rolling mills now in use than any other concern in the United States.

For a number of years past this concern has made a feature of the heaviest type of blowing engines, riveting machines, compound mill engines, and blooming, plate, rail, and universal mills.

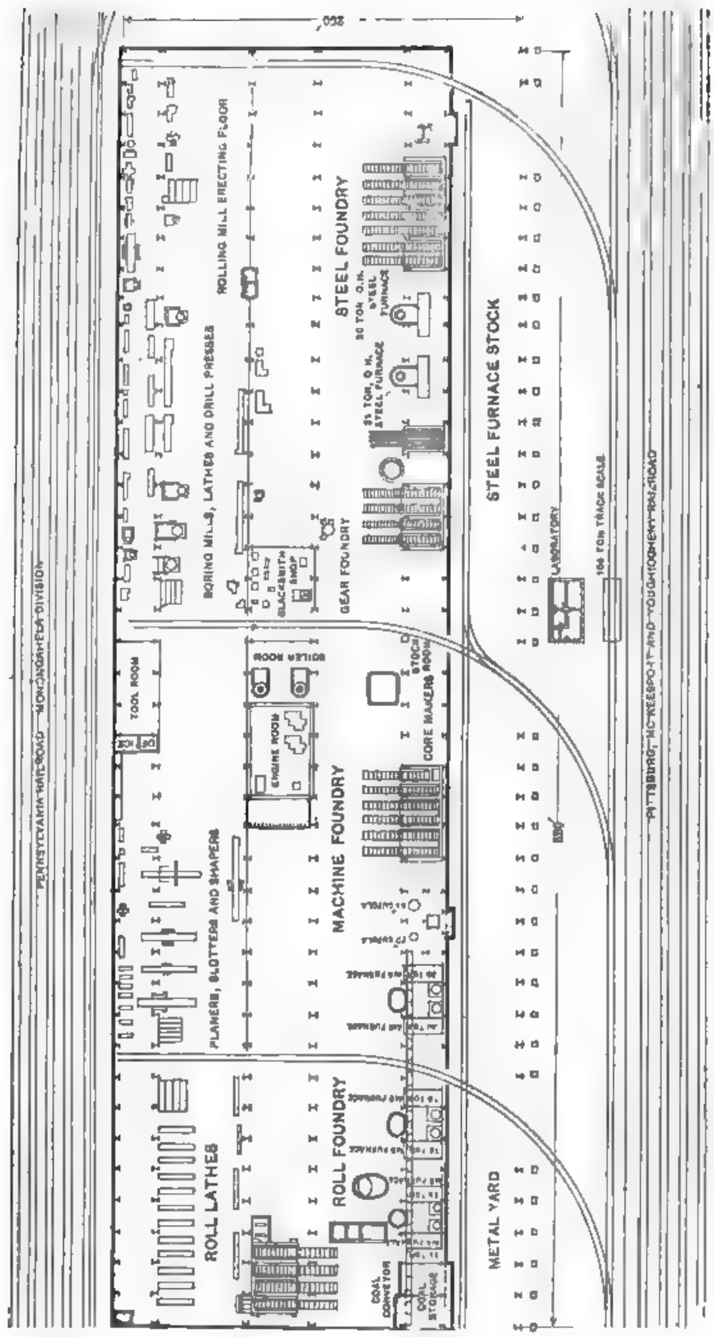


FIG. 69.—PLAN OF THE FOUNDRIES, ETC., OF THE MESTA MACHINE CO., PITTSBURG.

Their contracts during recent years have included two plate, two slabbing, two beam, and two universal mills for the Homestead Works, and a large amount of the work called for by the Duquesne, Lorain, Cambria, and other leading concerns, embracing the Mingo Junction plant of the National Steel Company, the Riverside Works at Wheeling, the Bellair Iron Works at Wheeling, the Wheeling Steel Company's Works, the Illinois Steel Company's Works, the works of the Colorado Fuel and Iron Company, the Newcastle Tinplate Works, the Sharon Steel Company's Works, etc.

The contracts on hand by the firm included a 40-in. blooming mill for the works of the St. Clair Steel Company—the property of the Crucible Steel Company—with steam equipment, and a 55 by 60-in. reversing engine; a 30-in. universal mill, with tables, and a 46 by 60-in. reversing engine for the Sharon Steel Company; a 40-in. blooming mill, and 55 by 60-in. reversing engines for the Colorado Steel Works; a 40-in. mill and a 72 by 60-in. tandem engine for the Kokoma Wire Company, Indiana; a 30-in. mill, and a 60 by 72-in. cross compound engine for the Sharon Steel Works; two 30-in. mills and 60 by 60-in. cross compound engines for the Colorado Company; and a 40-in. mill for the Duquesne Steel Works. The design and construction of heavy shears is a notable feature of these works, and among those now on hand, to be driven by steam power, is one that will cut 8 by 24 in.; one to cut 4 by 24 in.; and one to cut 4 by 40 in.; while in this line of work the firm has made a single casting weighing 67 tons for the bed of a hydraulic shears. Another example of heavy work produced is furnished by the housing of the 40-in. blooming mill now being built for the St. Clair Steel Works of the Crucible Steel Company.

It rarely happens that works of this description call for much notice apart from their products. This case is no exception to the rule. Indeed, the works are old, as American works go, and rather cramped for space, being built in on all sides. Nevertheless, they have turned out some of the most notable pieces of work that go to make up American foundry engineering records, including steel castings up to 38 tons. The foundry is the largest and most interesting feature of the works. Here there are two 15-ton melting furnaces, which are used for castings of the largest size. Steel castings are nearly altogether used for roll gearing and housings. No machine moulding is applied. The works are commanded by 14 electric cranes. The general rates of wages paid are:—

Moulders and founders	$3\frac{1}{2}$ dols. per day.
Men making moulds	$4\frac{1}{2}$ " "
Labourers	$1\frac{1}{2}$ " "

The hours worked average nine per day. Mr. Hemphill informed me that in Pittsburg the rate of wages paid for the same class of work was 33 per cent. more than in Philadelphia.

The extent to which the output of steel is likely to be increased in the future, and the character of plant adopted, are indicated by the fact that this one firm has now on hand four 40-in. mills for the works at St. Clair, Cambria, Duquesne, and Colorado. All of these mills are geared instead of being direct.

CHAPTER XIV.

Iron and Steel Foundries and Foundry Operations.

Extent of Foundry Interest and Pig Supplies.

THE foundry business of the United States is of large extent, and is entitled to consideration as representing in many ways the most advanced practice in any country. This is almost a necessary consequence of the infinite variety of uses to which foundry products are applied in American engineering workshops, and the recent large development of the iron trade generally.

Of the 16 million odd tons of pig-iron produced in the United States in 1901, probably 11½ million tons were applied to the manufacture of steel by various processes, while the great bulk of the remainder was used in foundry practice. If we include steel castings, the quantity of pig-iron worked up in foundries would be larger.

The colossal extent of the foundry interest of the United States may be roughly indicated by some recent statistics, collected and issued by an American trade journal (*The Foundry*) which show that there are 4,620 foundries in which iron is melted, varying in importance from a heat once in three months or longer to concerns melting hundreds of tons daily. Pennsylvania heads the list with 646; New York is second with 515; Ohio third with 400; Illinois fourth with 298; Michigan fifth with 230; and Indiana sixth with 185. Of cities in the United States that are centres of the foundry industry, Chicago takes the lead, with Philadelphia, Pittsburg, New York and Brooklyn in order as named, the highest total being 83 and the lowest 73. As might be expected, it is shown that where iron manufactures are most in evidence, the foundry trade has its chief business centres.

The foundry interest draws its supplies of pig-iron over a very wide area. In the Pittsburg district, and in New York, Pennsylvania and West Virginia generally, the relative proportions of foundry iron produced are inconsiderable. A good deal of the foundry iron is produced in the southern States, and especially in the States of Alabama and Tennessee, which send their products pretty nearly all over the country.

It is a prevalent custom among iron-founders to mix their foundry iron, and, generally speaking, the founder who has acquired the greatest experience and skill in making mixtures is thereby enabled to secure the greatest reputation. The varieties known as Ohio soft and American Scotch foundry irons are obtained by mixing local silicious ores and cinder, in the near neighbourhood of Pittsburg, with Lake ores, which give a soft and strong iron, free from excessive amounts of sulphur, phosphorus and manganese, and having rather large quantities of silicon.

The furnaces of the south have to deal with an ore which is silicious and carries relatively large quantities of phosphorus, and a coke which usually carries more sulphur than the Connellsville. The furnaces producing "local coke foundry," use a rich ore, and with low fuel consump-

tion, make an iron strong on account of its freedom from sulphur and phosphorus, but with relatively low silicon.

A recent writer has pointed out that in the United States the impossibility of always making an iron suitable for a particular purpose and of knowing what kind of iron would run from the furnace until it was cooled and examined led to the divorce of the furnace from the foundry business, the two businesses being formerly combined, as is shown by the fact that the superintendent of the furnace is yet called the founder.

The following are typical specifications for chemical composition of American foundry irons :—

Special Hard Iron (Close Grained).

Silicon must be between 1·20 and 1·60 per cent. (Below 1·20 the metal will be too hard to machine ; above 1·60 it is liable to be porous unless much scrap be used.)

Sulphur must not exceed 0·095 per cent., and any casting showing on analysis 0·115 or more of sulphur will be the cause for rejectment of the entire mix. (Above 0·115 per cent., sulphur produces high shrinkage, shortness and "brittle hard" iron.)

Phosphorus should be kept below 0·70 per cent., unless specified for special thin castings. (High phosphorus gives brittle castings, under impact.)

Manganese should not be above 0·70 per cent., except in special chilled work.

Medium Iron.

Silicon to be between 1·40 and 2 per cent. (Silicon at 1·50 gives the best wearing result for gears.)

Sulphur must not exceed 0·085 per cent., and any casting showing on analysis 0·095 per cent. or more of sulphur will be the cause for rejectment of the entire mix. (Sulphur preferred at 0·075 to 0·080 per cent.)

Phosphorus should be kept below 0·70 per cent., except in special work.

Manganese should be below 0·70 unless otherwise specified.

Soft Iron.

Silicon must not be less than 2·20 or more than 2·80 per cent., with a preference for about 2·40. (Below 2·20 per cent. small castings will be very hard ; above 2·80 large castings will be somewhat weak and have an open grain.)

Sulphur in no case must exceed 0·085 per cent. High sulphur makes iron "brittle short" and causes excessive shrinkage.

For frictional wear in brake shoes, etc., the sulphur may run up to 0·150 per cent.

Phosphorus should be kept below 0·70 per cent., except in cases where great fluidity is required, as in thin stove plate, when it may run up to 1·25 per cent. Phosphorus makes iron brittle under impact.

Manganese should be kept below 0·70 per cent., except in chilled work. For a heavy chill the manganese may vary from 0·70 to 1·25 per cent.

Foundry Mechanical Appliances.

No one can visit an American foundry of the latest design without being much struck with the remarkable improvements which recent years have brought about in mechanical equipment. Electric or other cranes, moulding machines, core boxes, and other appliances have come into much more general use than formerly. Cupola practice has been greatly improved and economised. The production and use of patterns are carried out in a much more scientific manner. The structures employed are better built, are more roomy, and are in other respects more up to date, and in the majority of the principal shops economy has been facilitated in other ways. Some of the latest types of foundries, both for pipes and for general castings, appear to leave little room for improvement.

The most perfunctory examination of the American trade journals devoted to the foundry interest will show how vast and varied is now the equipment placed at the command of the American founder to-day, compared with that of only a few years ago. It is not too much to say that hundreds of engineers and manufacturers are now catering for the founders' business where probably there were not tens so occupied less than 20 years ago.

This result has been mainly due to the general adoption of superior equipment and plant, but it has been largely facilitated by the general adoption of a system of piece work which makes the individual workman feel a personal interest in the business, by the introduction of more rapid methods of analysis, and by a more capable *personnel* generally.

Castings of very large dimensions are still generally excluded from the use of moulding machines, notwithstanding that the capacities of such machines have been greatly increased. Castings of great depth and intricacy are not well suited to this method. But work having a considerable amount of detail, provided it is shallow, is said to be usually adapted for the machine. A recent author states that "Fairly deep work, provided it is plain, is much better lifted by machine than by hand. But a machine will lift only vertically, while some patterns have to be drawn out at an angle, or with a special twist ; or draw-backs, or loose rings of sand will modify matters so much that the machine would rather complicate than simplify moulding. Work with middle parts is not adapted for machine moulding. Cylindrical sections are highly adaptable. The best of all is that which is shallow and easy to ram and deliver. And the highest economies are obtained by the grouping of numerous small pieces on one plate. It is obvious that for work in which the making, setting, and fixing of cores occupies more time than the actual moulding of the pattern, the economies of machine moulding are not so great as that in which the conditions are reversed."

In the case of one of the most recent foundries built in the United States—that of the Seaboard Steel Casting Company, of Chester, Pa.—10 cranes were required for the needs of the foundry and machine shops of the company, and the *Iron Age* states that each was specially designed for the particular class of work required of it. All the cranes are furnished with large motors in order to meet any emergency and prevent delays and interruptions caused by breakdowns, etc., due to

heavy overloading. All parts of the cranes of similar capacity are interchangeable. One of the features of the design of these cranes is that the gear wheels are cut from solid blanks of open-hearth steel of 60,000 lbs. tensile strength, in order to obtain the maximum strength. Five cranes are of 50-ft. span each, and serve the main floor of the foundry, all travelling on one runway, extending the length of the building, some 560 ft. They consist of two of 30 tons capacity each, one of 25 tons capacity, and two of 10 tons capacity each. This may be regarded as a typical American foundry crane equipment of the most modern kind.

Analysis versus Fracture of Pig-Iron.

When I was in Philadelphia I accepted an invitation from Mr. Outerbridge, one of the best known authorities on American foundry practice, to visit the important foundry there under his control, and I learned from him that there appears to be every appearance that chemical analysis will, before long, be wholly substituted in the United States for fracture, as a test of quality. Most American founders are now specifying analysis for this purpose, and hence the very rapid advance in the use of pig-iron casting machines, which are found in a number of the leading iron works.

On the other hand, it is agreed that "the purchase of pig-iron by analysis would lead to more dissatisfaction than by fracture, because the openness of the grain is very important. It would amount to a guarantee on the part of the furnace. If a second analysis was made it would not agree with the first. It is never claimed that anything but silicon would be guaranteed, but total carbon is of as much importance as silicon. If the founder knows enough about iron to know the approximate silicon by the fracture, he will be able to buy silicon cheaper by fracture, and if the iron happens to be deficient in silicon it is easily made up."

The friends of fracture stoutly maintain that of two irons having the same chemical composition, the one having the most open grain will make the best castings, because it was made at a higher temperature. This is a theory that finds pretty general acceptance in Great Britain, but the leaders of foundry practice on the other side of the Atlantic look upon this idea as more or less exploded.

American Foundry Costs.

The cost of the American foundry castings was recently declared* to have varied per 100 lbs., at typical foundries, as follows :—

	1901. dols.	1900. dols.	1899. dols.	1898. dols.
Cost of Materials and labour—				
Metals	0·7694	0·8479	0·4642	0·4589
Melting	0·0430	0·0453	0·0380	0·0368
Moulding	0·0080	0·0072	0·0065	0·0062
Cores	0·0161	0·0138	0·0123	0·0138
Salaries	0·4729	0·4550	0·4117	0·9985
Miscellaneous expenses... ...	0·0583	1·4266	1·0097	0·9985
Cost per 100 lb. castings ...	1·3683	1·4206	1·0097	0·0885
Defective castings, per cent. ...	5·8	2·2	2·1	2·5

* Bulletin of the American Foundrymen's Association, February, 1902.

From this statement it would seem that the cost of producing foundry castings in the United States has increased of late years under every head, the total advance being nearly 50 per cent., while the percentage of defectives has increased ; but the former result is mainly due to the boom, and the latter is merely accidental.

Foundrymen's Associations.

There are several Foundrymen's Associations in the United States, established for the purpose of discussing, and comparing notes on, the technical and commercial aspects of foundry operations, and no one can doubt that these societies have been very helpful to the owners, managers and foremen of foundry works. Their discussions generally assume a very practical shape, and point to increase of economy, wherever practicable.

The American Foundrymen's Association was established less than six years ago, to bring foundrymen together, and the association, to use the words of its fifth annual report, "came to life in a period when methods began to change, partly through the exigencies of the hardest times this country has ever passed through, and then again by reason of rapid developments to be credited to our investigators. There was an adequacy of foundry practice to be discussed by those who were anxious to keep in the front rank as producers at conventions, the main features of which had been drifting to the incidental entertainment. Gradually, however, matters of daily practice were fairly well discussed, and the achievements of the 'industrial engineer,' in lines other than ours, beginning to be felt most uncomfortably by those of us who supply the enormous tonnage he consumes, attention was perforce turned to the subject of rapid production of castings at selling prices far below anything we have ever known."

The better training of future foundry managers has received the attention of the American Foundrymen's Association. The establishment of a department for foundry theory and practice has been strongly recommended in the case of the Carnegie Technical School. American Universities have also taken an interest in the matter. "The consensus of opinion seems to be," to quote the report of the association named, "that, pending special equipment for the purpose, instruction should be given in foundry practice by lectures and regular visits to the more advanced foundries of the respective districts. Summer classes should be formed for the students who wished to make this their life work, or they should become volunteers in order to learn what they can of the practical operations of foundry procedure. Once the foundry becomes the desirable field for technical students it should be, and the institutions for learning are enabled to add foundry apparatus to their equipment, plenty of use will be found for it, not only for teaching the various branches of the industry, but for advanced investigation, and consequent benefit to the students."

The Manufacture of Steel Castings.

This branch of the steel industry has of late years made notable progress, and the total output is now about 250,000 tons a year. The

greater part of this output is got from open-hearth furnaces. In the year 1900, 177,491 tons of castings were produced by the open-hearth process, 134,847 tons being acid, and 42,644 tons being basic steel. Of the total stated, Pennsylvania alone produced 78,584 tons; the New England States, New York and New Jersey, 21,883 tons; and other States, including Illinois and Ohio, 77,024 tons.

The use of steel castings is extending in many different directions, and it is very clear to the student of American metallurgical practice that it is bound to increase still further; for rolls, pieces of machinery, wheels of all kinds, and numerous other uses on a large scale, formerly provided for by forgings, chilled iron castings, or otherwise, steel castings are coming into regular employment. I went over several steel foundries—among others, those of the Midvale Steel Company, at Nicetown, Philadelphia, and of Messrs. Mackintosh, Hemphill & Company, at Pittsburg, and was struck with the fact that almost every concern of any importance in the country now seems to deem it a necessity to have its foundry usually equipped with at least one or two open-hearth furnaces ranging from 8 tons to 15 tons capacity, and otherwise laid out much as at home. In numerous cases, the castings are finished by machine tools of a more or less specially American type, and largely electrically driven, each with its own motor.

The largest individual application of steel castings promised in the immediate future is that now projected by Mr. C. T. Schoen, Mr. Frick, and others, who are erecting large works near Pittsburg, for the purpose of casting railway wheels. This enterprise, like the Pressed Steel Car Company, is conceived and is being constructed on a large scale. I had the opportunity at Philadelphia of meeting the engineer who is responsible for the design of the special machinery that is being provided for the new industry. He gave me some interesting particulars of the work he had in hand, and intimated his belief that the company would be able to produce cast-steel wheels at 18 dols. a set, which, in his opinion, would enable them to displace the chilled wheels now so largely used in the United States, and sold, I am informed, at about 45 dols. a set. The casting of armour-plates has also been talked about, although no actual work has been done in this direction. I may, however, point out that this is not an American idea, Mr. John Spencer, of the Newburn Steel Works, Newcastle, having brought out a patent for this purpose many years ago.

The first soft steel castings, such as are used for gun carriages, that were made in the United States, and which were subjected to a ballistic test, were made in 1886 and 1887, by the Midvale Steel Company, who were the pioneers in this work. Steel castings, however, had been successfully made in the United States at least as early as 1867. In July of that year, the Wm. Butcher Steel Works, now the Midvale Steel Works, cast some crossing frogs for the Philadelphia and Reading Railroad, of crucible steel. It is recorded that the moulds were made of ground firebrick, black-lead crucible pots ground fine, and fire clay, and washed with a black-lead wash.

As an instance of how far large foundries depend upon iron and steel works, I may name the case of the important cast-iron foundry at the Edgar-Thomson Works, which employs 315 men, and produces an

average of 150 tons of moulds, etc., per day, as well as 25 to 30 tons of stools for the ingot moulds, and 50 tons of general castings. The whole of the steel castings used throughout the Carnegie Works are produced here. Brass castings are produced in a separate shop, principally for tuyeres, to the extent of about two tons per day. Direct iron from the blast furnaces is used in the foundry. Rolls are produced here from charcoal iron. All the iron used in the foundry is put through a mixer.

It has been stated that to-day large steel castings that are perfectly satisfactory can be produced, while it is almost impossible to get good small ones. This is explained by the fact that while most steel castings are made by the open-hearth process, in furnaces that usually melt from five to 20 tons, to pour even five tons of steel into castings averaging 100 lbs. in weight would, as a rule, take so long that those poured last would be of inferior quality on account of the cooling of the metal. As a rule a large portion of the heat is poured into a comparatively few large castings, and the remainder put into the smaller ones.

The Camden Iron Works and American Foundry Practice.

Having settled on the desirability of obtaining some information as to the special features of the American foundry practice, I made up my mind, when in Philadelphia, to ask for permission to go over the Camden Works of my old friends, Mr. Walter Wood and Mr. Stuart Wood, who are well known in the cast-iron pipe trade of the United States.

I was the more impelled to visit these works, because for some three years they had secured the pipe contracts of the Glasgow Corporation, and I was assured by Mr. Walter Wood, not only that those contracts had not been taken at a loss, to provide for the needs of the "law of surplus," but that the firm had made, on the whole, a larger profit on these contracts than on the average of their home orders. "Indeed," added Mr. Wood, "we make it a rule to sell nothing without a profit."

If the pig-iron had been produced on the spot, the success of this firm in securing British contracts would not have been so difficult to understand, but I was informed by Mr. Wood that the foundry pig-iron used at the Camden Works is mainly obtained from Birmingham, Ala., nearly a thousand miles distant, and has to be conveyed all the way by rail, while the pipes have to be transported by rail from the Camden Works to the river Delaware, lightered several miles, thence transhipped and sent across the ocean to Glasgow, paying Clyde harbour dues and other charges as well as the cost of loading and unloading.

Again, I learned that at the Camden Works the wages paid are above rather than below the average, the moulders being paid 3 dols., and ordinary labourers 1 dol. 25 cents per day, the machine labourers 15 cents per hour, machinists 30 cents per hour, and other workmen proportionate rates. When I coupled these wages with the irregular and by no means well-arranged style of the works, I was nonplussed at the result.

There are two things that appear to greatly aid the Camden Pipe Works in their competition with Great Britain. One of these is the bonus system which prevails; the other is the practice of having, as far as possible, what are called "big runs" on particular contracts or classes of work. In fixing the bonus the custom is to estimate the time that will be required to do a particular piece of work, and to say to the workman: "If you can do this work in eight days instead of ten, you will have ten days' pay." The usual week's work is 60 hours. The firm do not employ union men, as such, and have no trouble with the union, which is not allowed in any way to fix the rate of wages. Nevertheless, I was informed that there has never been any strike at the Camden Works.

It struck me that there was good supervision and administration in all the departments of the works. In the machine shop there is one foreman for every 45 workmen. In the foundries there is only one foreman to every 130 workmen. The total number of hands in the foundries and machine shops is 775, and in all departments 1,100 are employed. In the foundries only 30 per cent. of the total hands employed are skilled, the rest being labourers, at 1 dol. 25 cents, or 5s. 2½d. per day. In the pipe shop there are many Slavs and Poles, and in the yard there are a number of negroes who handle the pig-iron, etc., while in the foundries some of the skilled workmen are English.

There are here other regulations affecting labour that deserve to be noted. In the week of my visit only 25 men out of a total of 1,100 had been absent from work on the Monday morning. No fines are levied for absence without leave, but if a man absents himself more than once or twice, or is under the influence of liquor, he is discharged. No smoking is allowed in the works.

The manager informed me that, in his experience, the average American workman was often found to do his work rapidly at the risk of efficiency, German workmen being the most painstaking.

At Camden, as at most of the other works visited, I found that every advantage is taken of possible economies in supplying materials and otherwise. In the making of cores, ordinary river clay is mixed with sharp sand, both being got in the near neighbourhood of the works. The firm make their own hay ropes, manufacture a large part of the tools and other equipment employed, and also produce their own gas from gas producers of their own design. The pipe fittings, bends, tees, etc., are all produced on the spot on a piece work basis. Small castings, to which one shop is entirely devoted, are given out at so much the hundred.

The Camden Works have produced pipes up to 72 inches diameter, and they recently produced cylinders of 13 ft. diameter as castings. In the green sand shop the patterns are smoothed up with plumbago, and two men will often put up for a day's work three moulds, to be used for the bearings for pumping engines. One man is expected to put up in a day the moulds for the side plate for a purifier, of which one-half is cored, the weight of the casting being about 1,100 lbs., and going deep into the flask.

Among the various labour-saving devices seen at Camden I was

most struck with the hydraulic rammer, which is a spindle with an enlarged end that fits into a socket and is rammed into the flask. This rammer is of the firm's own design, and does its work both economically and efficiently, under a pressure of 300 lbs. There are, however, numerous cases in which this tool cannot be used. If the end of the pipe is in any way exceptional, or if it is not of full diameter throughout, hand ramming has to be resorted to. In one casting pit two or three hydraulic rammers are employed. Among other mechanical details, I noted that pneumatic hammers are used to chip the castings.

The Camden Works do a considerable business in the production of foundry castings of different kinds, which they have made up to 33 tons, but hitherto the capacity has been limited by the power of the crane, and hence at the time of my visit a new 40-ton electric crane was being supplied, as well as a new machine shop of considerable size. Complete flasks are used, nothing being bedded in, as is usual in some cases. For heavy pieces, the flasks are built up with brick and loam. All patterns are prepared in the pattern shop, and on green or dry sand castings the complete pattern, after having been made, is split in two pieces—one lower and the other upper,—the flask then being opened and smoothed up with plumbago. For many loam castings no pattern is previously prepared. For cylindrical pieces a "sweep" is used, this being a board cut to conform with the shape of the casting, which is placed on a cylindrical spindle and rotated, while brickwork is built up round about it.

Having given a general idea of the economic situation at Camden Works, I am still puzzled to understand how they can produce pipes in competition with Glasgow founders at that city. No doubt at the time that the Glasgow and other contracts were taken by Messrs. Wood, the prices of American pig-iron were very low, but there is usually a difference of 3½ to 4 dols. in the price of Birmingham, Ala., and Pittsburg No. 1 foundry iron at works, and it is improbable that either description was ever delivered at Camden Works for less than 40s. per ton, while we have seen that wages are much higher at Philadelphia, bulk has to be broken twice before reaching the ocean, which is practically a hundred miles from Camden, and ocean freight has to be paid on a bulky and inconvenient form of cargo. On the whole, I am disposed to doubt whether this competition is likely to be repeated on a scale of any importance, and it certainly ought not to be if British founders attend to their business.

CHAPTER XV.

The Electrical Development of the United States.

The Recent Progress of the System.

PROMINENT among the influences that have both revolutionised the economical conditions under which iron and steel can be produced, and have created an extent of demand for those materials that could hardly have been believed to be possible only a few years ago, must be placed the great industry which deals with the generation and application of electric power. When I visited Pittsburg in 1890, I was presented with a very interesting work, which gave a historical account of the development of the principal industries of that city, in which electrical plants are not at all mentioned. Even at a somewhat later date electrical power had been but little applied to industrial operations and to machine tools. By the date of the Chicago Exhibition of 1893, however, all this had been more or less changed. At that notable and never-to-be-forgotten display of the world's manufactures and achievements, no less than 478 distinct exhibits were contributed by the United States, 18 by Great Britain, 45 by Germany, and 94 by France. At the World's Fair the operations of the electrical companies were mainly missionary and experimental; very little had been done to demonstrate the great inherent merits of electricity as a source of industrial power. The Westinghouse exhibits at Chicago were chiefly designed to illustrate how electricity could be carried over long distances, and transformed as desired for commercial uses. All the large Westinghouse dynamos of that day were of the two-phase type, and the dynamo of 1,000-h.p., shown by Siemens & Halske, of Berlin, as well as the great German search light, with a 7½ ft. projector, were accounted among the most wonderful things at the Exhibition. The rapid advances made by the American electrical firms may be typified by the progress of the General Electric Company of that day, which had begun operations 15 years before with only five employés, and in 1893 had raised that number to about 1,100. Similar, and in some cases even more remarkable, progress had been achieved by the Westinghouse and kindred enterprises.

Both previously and directly subsequent to the Chicago Exhibition, electricity had made great advances, both in a technical and in a practical direction. The stimulus given to its use by the parade of its latent powers made at Chicago, led to its application to traction, haulage, transmission of power, heating, welding, and many other purposes, on an extensive scale. Its progress for railway purposes was rapid. In 1887 there were only 50 miles of electric railway in the United States; in 1893 this figure had increased to 6,000 miles. Similarly, the American mileage of electric tramways had increased

from less than 5,000 to over 12,000 miles at the middle of 1893, and in 1892 alone 1,066 miles of electric tramways were constructed, and 1,984 miles were converted.*

In the early "nineties" electricity was being applied on a rapidly increasing scale to power purposes. The Creusot Works, with characteristic enterprise, after applying electric power to a 45-ton crane originally worked on the flying rope system, installed a 60-ton electric crane, and in 1893 added a 150-ton crane on the same system. Electric power was about the same time applied to drills and rock-breakers by the Thomson-Houston Company, of Boston. In 1890 I had the pleasure of arranging with Professor Elihu Thomson, the head of this important enterprise, to furnish a paper for the New York meeting of the Iron and Steel Institute on the progress achieved up to that time in applying electric power to the welding of iron and steel,† a perusal of which will show that this system had come up so early as 1886, that it had in 1890 come to be largely applied to join sections of wire into one length, and that the behaviour of soft iron, and of the milder grades of steel had been found particularly favourable to the welding operation. In the latter part of 1893, a 1,000-h.p. electric motor had been built to test the feasibility of handling freight at terminal yards in Chicago,‡ and electric power had been applied to elevators and many other purposes. Electric tramway cars began to become general in the years 1893-94, and an electric trolley system was applied to canal boat propulsion in the winter of the former year.§ But up to this time very little indeed had been done in applying electrical plant to industrial purposes, and more particularly to the needs of the steel-plant and the machine shop.

Among the electrical applications now making rapid advances, and promising a large field for economy in the future, mining operations claim a prominent if not also a pre-eminent place. A fruitful combination, with this end in view, is that of the Baldwin Locomotive Works and the Westinghouse Electric Company. When I was at the works of the latter firm, in Pittsburg, I was handed a few of their principal publications, and among others that of their electric locomotives for mine haulage. I find here recorded several examples where "the cost of haulage has decreased from 10 cents (5d.) a ton with mule haulage, to less than 1 cent (½d.) per ton with electric locomotives," and where "the saving brought about by electric haulage amounts to 30 per cent. upon the sum invested in the power plant."

Between the achievements in the electrical field of ten years ago and those of to-day what a vast gulf has been bridged over. The actual work now on hand by the Westinghouse Electrical Company, of Pittsburg, embraces such *tours de force* as eight 5,000-kilowatt Westinghouse 11,000-volt three-phase revolving field alternating current generators, with an overload capacity up to 7,500 kilowatts each, and twenty-six 1,500-kilowatt Westinghouse rotary converters, both of these being the largest hitherto constructed. They will be supplemented

* *Organ für die Fortschritte des Eisenbahnwesens.*

† "On Welding by Electricity." *Journal of the Iron and Steel Institute*, II., 1890.

‡ *Electrical Engineer* (New York), Oct., 1893.

§ *Electrical World* (New York), Nov. 18th, 1893.

with seventy-eight 550-kilowatt Westinghouse air blast transformers, with all auxiliary apparatus. This is only one of a number of similar contracts which this company had on hand at the time of my visit, and was for the Manhattan Railway power-house. Similar contracts were on hand for the Metropolitan Street Railway (N.Y.), for the New York Edison Company, for the United Electric Light and Power Company, for the Manhattan Hotel (N.Y.), for the Brooklyn Rapid Transit Company, for the North Jersey Steel Railway Company, and others, the whole aggregating, at quite a recent date, about one million h.p. of Westinghouse electrical and steam apparatus in New York City and its vicinity alone.

All this is named because of two characteristics which are likely to be obvious to the reader—the first the colossal dimensions of much of the electrical equipment now employed, and the consequently heavy weight of iron and steel called for; and the second, because it illustrates, by the experience of only one firm out of many, the vast amount of electrical work that is now being carried out all up and down the country, for railways, tramways, power purposes, electric lighting, and in many other ways.

The demands of the future are likely to increase at least as rapidly as those of the past. Take the case of power transmission plants alone. In the United States, at any rate, the plant at San Bernardino, which began in 1892, using 10,000 volts and transmitting 30 miles, may be regarded as the pioneer of its kind.* A good deal of trouble caused this movement to advance but slowly for years afterwards. Since then 40,000 volts have been used to transmit power for 35 miles (in Utah), where the line reaches an extreme height of 10,000 ft. above sea level, and experts have declared that while voltages of 15,000 or 20,000 can be used without insuperable difficulty, "no new or modified system of transmission will be required before 50,000 or 60,000 volts can be employed for distances up to 150 or 200 miles."†

Electrical Power in Iron, Steel, and Engineering Works.

Of the recent advances that have been conspicuous in iron, steel, and engineering works, I need say but little here, because they are so all but universal that their mere enumeration would fill a catalogue. Examples of such applications will be found scattered throughout these Reports. Briefly, it may be stated here that there is hardly a process carried out in iron works, steel works, or kindred establishments throughout the United States, to which electricity is not applied on a greater or lesser scale, and that in the workshops of manufacturing engineers, one of the chief problems of the last few years has been that of how best to adapt every form and application of mechanical power to electric driving. Every student of industrial economies must be struck with the success that has been reached in both directions.

* In saying this the Frankfort-Lauffen experimental transmission line of 30,000 volts is not overlooked, but it was not American.

† "High-voltage Power Transmission," Vol. XV., Pro. Am. Inst. E.E

Recent Advances.

In the steel rail works of the United States some remarkable applications of electric power have taken place. One case is recorded where electric plant was contrived so as to pass in the steel blooms or ingots at one end of a set of rail mills, and to bring them out at the other end as finished rails, whereby, it is said, the number of hands employed was reduced by one-third, concurrently with an increase of nearly 40 per cent. in the output.

The general features of the applications of electricity to engineering plant in the United States do not differ from our own, and consist in the attachment of the motor to each individual tool, so as to revolve the main shaft by gearing; the building of the armature of the motor on the main shaft and concentric with it, so as to revolve it without gearing; its substitution for main or section driving belts. All this permits of the grouping of the entire steam plant under one roof.

In a number of the machine tool shops of the United States, it is the practice to bring the smaller tools to the casting to be operated on, instead of conveying the casting to the tools. This is much more easily done in the case of such machines as have motors fixed in the tool frame. It is not a unique thing to see as many as four drilling or milling machines grouped around a large casting at the same time, each working independently. The same thing is done with emery wheels, when driven by small self-contained motors, which are set to work on castings or other structures while other tools are being operated.

Some engineers have recommended that small tools should be grouped and run by belting from one overhead motor rather than have a direct-acting motor attached to each of them. Several of the largest American firms have meanwhile for years past been applying their engines to the perfecting of direct-connected motors for machines of every kind, and new departures in this direction are daily coming forward.

The Works of the Westinghouse Electrical Manufacturing Company at Pittsburg.

When at Pittsburg, I took advantage of the opportunity, kindly offered me by the British Westinghouse Company, before I left home to go over the works of the Westinghouse Company, at East Pittsburg. There I was introduced to Mr. McFarland, the vice-president, Mr. L. A. Osborne, the works manager, and Mr. Loud, the manager of the works at Trafford Park, Manchester, from whom I ascertained most of the particulars I have here noted, in the course of a too short examination of these remarkable works.

The Westinghouse Electrical Works, at East Pittsburg, employ about 6,000 men and women, the latter being mainly employed in such light work as splitting mica and welding coils. The company have other three factories in the United States—one in Cleveland O. which employs about 600 hands, another at Newark, N.J., and a third—which is mainly an incandescent lamp factory—in New

York. The main business of the Pittsburg works is to build generators of all sizes, from one to 5,000 kilowatts.

In the electrical field, perhaps no American concern quite holds the same prominent place as the Westinghouse Company, which recently increased its capitalisation from 15 to 25 million dols. (three to five millions sterling), and the sales of which, in 1901, were nearly a million sterling in excess of those of the previous year.

One of the largest contracts ever placed in the electrical world was being executed by the Westinghouse Company at the time I went over their works. This was the contract from the Manhattan Elevated Railroad, already named, for eight generators of 10,000-h.p. each, and of an aggregate value of a million sterling.

The buildings that form the establishment of the Westinghouse Company at East Pittsburg are almost unique of their kind, and have only been built a few years, the original factory having been located in Pittsburg. There are here 4,000 machine tools of all kinds, and many hundred motors. Power is conveyed to the motors by overhead wires, and the motors are generally placed above the floor level, so as not to take up more floor space than is absolutely required. In a number of cases the motors are attached to the machines. Among the work which the company had on hand at the time of my visit, the most notable was the 5,000-kilowatt machines for the Manhattan Elevated Railroad in New York, which are so enormous that the company had to build an entirely new shop, 70 ft. in height, and provide an entirely new equipment of tools, in order to handle them. This fact shows how ready American firms are to adapt themselves to the requirements of their customers, at whatever cost. The steel castings for this immense piece of work were, somewhat strangely as one may think, not provided by a Pittsburg firm, which is the most likely thing to have happened, but by Messrs. B. Atha & Co., of New Jersey, and were brought nearly 500 miles by rail to the Westinghouse factory. I wish I could give the details of these great generators, but space will not permit.

The shops of the company are fitted up with every known contrivance for the economy of time and labour, as might be expected, including large tubes, similar to the post office system, whereby letters are conveyed from one department to another. Numerous electric cranes, up to 50 tons, are found in every aisle. The equipment, as a whole, is perhaps not excelled in the whole of the United States, and certainly not within my knowledge.

During the last three years the works of the Westinghouse Company at Pittsburg have been practically doubled in size. Some 60 per cent. of the work produced is supplied for power purposes. I asked Mr. McFarland whether the experience of his company favoured the idea that the electric railway would come into use for freight traffic? In the States inter-urban roads often practically parallel street railroads. The growth of passenger traffic by electric roads has recently been phenomenal. Such roads are generally maintained in a condition of considerable efficiency, and trains are run at a high rate of speed. I may specially name the electric roads from Pittsburg to East Pittsburg and to McKeesport. The use of electric lines for considerable

distances is astounding, and the Westinghouse Company have built a line 75 miles long at Detroit, and a 35-mile line from Seattle to Tacoma, while other similar lines are projected or in progress. Nevertheless, I learned that in the opinion of Mr. Westinghouse himself the displacement of steam by electric lines, if it ever comes about on a large scale, must be of slow growth, and it is not likely, at present, at least, to apply at all to the main trunk lines.

Some Features of Electrical Equipments.

I learned from Mr. McFarland that the Westinghouse Company are doing a large business in fitting up the newest iron and steel works in the United States with alternating current equipment, including the works of Spang, Chalfant & Company at Pittsburg, of the Dominion Iron and Steel Company at Sydney, Cape Breton, of the Crucible Steel Company at Pittsburg, and of the Colonial Steel Company at Monessen, near Pittsburg. The alternating current has made more rapid progress than its rival system within recent years, but it was not until 1894, when a satisfactory induction motor could be relied on, that it made real headway. Indeed, it is only a few years ago that it was considered very dangerous, and Mr. McFarland informed me that attempts were made through the Legislature to prohibit its use.

The tendency in American steel works practice is to employ electric motors for every purpose to which they can be applied ; thus, at the new pipe and tube mills of Spang, Chalfant & Company, they are being applied to practically every purpose—hoists, cranes, charging machines, machine tools, etc. At the Edgar-Thomson and other works, practically everything is done by electricity except the handling of the ladles, which are operated by hydraulic power or otherwise.

The visitor to the newest iron and steel plants of the United States cannot but be struck with the remarkable progress that is being made in the application of electricity to all ordinary mechanical work, to transport, to mining, and to other purposes. No enterprise appears to be regarded as well to the front unless electric power is applied on as large a scale as possible. It is more especially universally applied to cranes, machine tools, and other power demands. Hence the fact that the works of the leading electrical companies have been largely increased in size and capacity, while 50 per cent. to 60 per cent. of the work of the leading firms is for power purposes. For transportation purposes electricity has not hitherto made so much headway in industrial works, but this seems to be regarded as an advance which will certainly happen in the future.

CHAPTER XVI.

American Shipbuilding.

THE maintenance of the shipbuilding supremacy of Great Britain is so essential to our iron industry, to which it is now the greatest individual contributor, that I deemed it my duty to make some inquiry into the actual circumstances and prospects of the shipbuilding industry of the United States, which is believed in some quarters to be on the eve of a notable and aggressive advance.

The official figures for the year 1900 show that the total tonnage of merchant vessels built in the United States was 365,791 tons, of which 129,973 tons were built on the Great Lakes, and 10,006 tons on the western rivers, leaving 225,812 tons for the seaboard, and of this latter figure 177,721 tons were built at Atlantic and Gulf ports. The total seaboard tonnage constructed in 1900 was a little over one-eighth of that built in the United Kingdom in the same year.

While the United States are thus far behind the United Kingdom in point of actual shipbuilding output, the progress of American enterprise and production in this direction has of late been very remarkable, a number of large yards having been erected, with the most modern plant and appliances, at the principal ports. Indeed, the shipbuilding industry of the United States, exclusive of the United States navy yards, according to a preliminary report of the Census Bureau, had a total invested capital of 76,699,651 dols. in 1900, which is an increase of 181 per cent. since 1890. The value of the products, including custom work and repairing, was 73,444,753 dols., an increase of almost 93 per cent. There were 1,983 establishments and 46,121 wage earners, with total wages of 24,388,109 dols.; miscellaneous expenses, 3,582,257 dols.; and the cost of the materials used was 33,031,280 dols.

In 1900, the shipyards on the Delaware River turned out 77 finished vessels, comprising 1 battleship, 1 cruiser, 1 torpedo-boat, 12 steamships, 5 steamboats, 18 tow-boats, 1 fire-boat, 2 schooners, 28 barges, 2 steam barges, 2 steam yachts, 1 naphtha barge, 1 gun barge, and 2 other small motor vessels not classified, the value of which exceeds 15,000,000 dols. (£3,000,000). In the early part of 1901, the New York Shipbuilding Company alone had under contract eight vessels of 124,900 tons displacement.

New York Shipbuilding Company's Works.

Nothing that I saw in the course of my visits impressed me more than the new shipbuilding works on the Delaware, built by the New York Shipbuilding Company, of which Mr. H. G. Morse is president and Mr. H. C. Frick, formerly president of the Carnegie Steel

Company, is a leading shareholder. Probably it is not too much to say that this establishment is in all respects the most modern and the most remarkable in the world, alike in respect of its vast size, its resources for economical production, its magnificent array of labour-saving appliances, its almost overpowering appearance of having been laid out without regard to cost, its admirably convenient location, and its evidence of high organising capacity. The company was founded in 1899 with a capital of £1,200,000, and at a later date it was determined to increase the capacity of the original plant about 50 per cent.

The New York Shipbuilding Company's yard on the New Jersey shore of the Delaware River, opposite Philadelphia, has a frontage on that river of 3,600 ft., and a width of about 1,800 ft., with a depth of water at low tide of 38 to 40 ft., the area of land occupied being 130 acres. The floor space of main shops is 18 acres, and there are four acres of skylight and two acres of window surface. There are six launching ways, each of which can accommodate a ship of 650 ft. long, and can be extended to 1,000 ft. There is a pier 72 ft. wide and 1,200 ft. long, in 30 ft. of water, an outfitting bulkhead 1,000 ft. long, and a timber wharf 500 ft. long. Power is furnished by electric, compressed air and hydraulic plants, the power-house being 175 ft. by 110 ft. The boilers are of 2,503-h.p., the main engines for the electric generators 750-h.p. each, and alternating current motors operate the larger machine tools, while 42 cranes, ranging from seven to 100 tons capacity, are operated by direct-current motors. In the main power-house is an Ingersoll-Sergeant air-compressor, capable of delivering 5,000 cubic ft. of air per minute. The air pressure carries 110 lbs. per square inch, and is distributed by mains reaching every part of the plant. About 300 portable riveters, caulkers, drills, etc., are in use. A high-pressure hydraulic system is furnished by two Barr pumps with a capacity of 400 gallons per minute. Two accumulators, one in the power-house, the other in the centre of the plant, are connected with the necessary pipes for the general distribution of this power, which is used chiefly for riveting. The pressure carried is 1,500 lbs. per square inch.

It is regarded as probable that from 4,000 to 5,000 men will be regularly employed, nearly all of them being skilled workmen.

It would almost seem to a layman (which is all I can claim to be in shipbuilding affairs, although I have for about thirty years been in the habit of visiting shipbuilding yards, and have seen over those of greatest note in this and other countries) as if there were but little possible in the way of economy that is not provided for in this plant. While in Philadelphia, in Pittsburg, and in New York, I was advised again and again to see it, as being the greatest achievement of American brains in its own special category. My advisers do not seem to me to have rated the achievement too highly. The establishment, to begin with, has a location equally convenient for receiving cheap supplies of raw material, for the command of cheap labour—which on the New Jersey side of the Delaware is considerably less than on the opposite shore—for access to the sea, and securing up-to-date plant and appliances of every kind, with the

most highly-skilled labour available in the foremost industrial State of the country—that of Pennsylvania. The shops are laid out in such a manner that there is no unnecessary handling of material and no retrograde movement in its treatment and application. Everything is on a colossal scale. The available space for every operation carried on, or likely to be called for, is more than ample. Many of the machines are entirely new and special in design. Furnaces are built to take 60-ft. angles in the angle shop. More than 100 tons of plates per day can be punched and sheared in the plate shop. Hydraulic power is used almost entirely for punching, and pneumatic tools for caulking, riveting, and chipping. Shears are provided to shear a 6-ft. plate of an inch thick. Roller bearings are applied to some of the principal machines. With one machine, of unique design, one man can do 600 holes per hour. One 100-ton crane over the slips—which are built under cover—runs at a height of 110 ft. from the ground, and has a span of 121 ft. 6 in. The building slips are 600 ft. long and 120 ft. wide. The planing machinery includes an interesting openside planer, which can do work almost up to any length, and deals with plates 8 ft. square.

As a rule the plates are received at the yard cut to shape, but the edges are planed here. Angles are ordered with about 3 in. margin on the length actually required, the difference being sheared in the yard. Castings and forgings are received in the rough and finished here. The timber is usually received by rafts in large balks, and is stored, dressed, and shaped on the ground.

In Pittsburg I had the advantage of hearing from Mr. McFarland, of the Westinghouse Company, a recognised authority on shipping and shipbuilding affairs, his high appreciation of the character of the New York Shipbuilding Company's yard and works. The whole plant is highly concentrated in its arrangements. It is so arranged that the materials all go forward in their passage, from the raw coal or other material to the finished ship. The 100-ton crane, said Mr. McFarland, is especially fine, and is adapted to lifting the engines and placing them direct on the bed-plate in the hold of the ship, which has in some cases been done.

Lake Shipbuilding.

When at Cleveland, O., I called on Mr. James Wallace, manager of the American Shipbuilding Company, which has here its head-quarters, and is the largest shipbuilding concern on the Great Lakes, if not in the United States. I was informed that this company is a consolidation of seven different enterprises, carried on at West Superior, Detroit, West Bay City, Lorain, Cleveland, Buffalo, and Milwaukee. It employs 9,000 hands, and pays 90,000 dols. per week in wages, so that its business is considerable.

The American Shipbuilding Company is mostly engaged in vessels for the lake trade. This is a branch of the shipbuilding industry that has greatly extended within recent years. During the five years ended 1894 the total tonnage built on the Great Lakes was only 213,000 tons, which in the five years ended 1900 had advanced to 470,000 tons. About 117,000 tons has been built in a single year.

Mr. Wallace does not believe that American shipbuilders are in any respects behind those of England. On the contrary, he informed me that he had been over several British yards, and he declares that our work is not got out so quickly as it should be. He particularly referred to what he described as the waste of labour involved in our making use of hydraulic instead of pneumatic riveting. They found on the Lakes that pneumatic riveting did the work quite as well in about one-third of the time; and he added that his firm were now riveting about seven-eighths of the entire vessels by the pneumatic system, which he challenged any British firm to equal.

The American Shipbuilding Company were building two vessels, each 450 ft. long, by 18 ft. wide, and 35 ft. deep, to carry 7,000 gross tons on the lakes—the *Northland* and the *Northman*. Mr. Wallace had no doubt that on the Great Lakes they could build ships quite as cheaply—if not more so—as in Britain, but they could not ship them conveniently, because of the restrictions on size imposed by the depth and width of the Welland Canal, which they would have to get through on their way from the Great Lakes to the St. Lawrence, and thence to the Atlantic. This canal can only take a vessel of 14 ft. draft and 43 ft. beam. The canal could not take a vessel more than 260 ft. long, but a larger boat could be handled by taking it to pieces at one end of the canal and reconstructing it at the other, and as a matter of fact this had been done with some boats built at Chicago.

A recent Report issued by the Secretary of the Treasury, remarks of the year 1900 that: "The new factor in lake shipbuilding—and one of great promise it is, too—is found in the commencement, on an extensive scale, of the construction of vessels for salt-water service. Of the 61 new vessels in lake yards, 10—all cargo carriers and of steel construction—are designed for ocean service. Eight of these vessels built for the Atlantic trade, or for either the ocean or lake service, as circumstances and rates may warrant, are of the maximum dimensions to permit their passage through the St. Lawrence canals—that is, vessels of about 3,000 tons capacity each Two of the vessels, for deep-water service are larger—will have, indeed, a cargo capacity close to 7,000 tons each. These vessels will have to be taken to the seaboard in sections, and will probably be re-erected at some point on the Lower St. Lawrence." So, *mutatis mutandis*, in 1901.

Comparison of Shipbuilding Contracts.

As to differences of cost in shipbuilding under the present conditions, I cannot do better than quote the case of recent contracts for two ships made by the Atlantic Transport Line, with Harland & Wolff, of Belfast, of exactly the same size, dimensions, and all particulars, as two ships contracted for with the New York Shipbuilding Company, of Camden, all in 1900. The cost of the English-built ship, as near as possible, is stated by the president of the Atlantic Transport Company to have been about £292,000 (1,419,120 dols.). The same description of ship built at the works of the New York Shipbuilding Company cost a little over £380,000 (1,846,800 dols.). In addition to this, the same company had two steamers with the New York

Shipbuilding Company, of smaller dimensions, under contract at £150,000 each (729,000 dols.); also two ships of exactly the same dimensions with the Maryland Steel Company, Sparrow's Point, for £150,000 each (729,000 dols.); while two ships of identically the same detail, delivered in the previous twelve months, built by Harland & Wolff, Belfast, cost £110,000 (534,000 dols.) and £100,000 (486,000 dols.). So far as these details supply a criterion of difference in cost, it would seem that the American prices are 30 per cent. to 36 per cent. above the English prices, although the American companies in question are probably about the best situated for work of the kind of any on the seaboard of the United States.

Nationality of Vessels Carrying American Trade.

Forty years ago the total value of the imports into the United States amounted to 338,768,130 dols., and of this 216,123,428 dols. worth was carried in American vessels, and 122,644,702 dols. in foreign vessels, so that 63·8 per cent. of the whole of the imports into the United States were brought in under the American flag. Since that year the percentage of imports carried in American ships has almost continuously declined. In 1900 the total imports were 805,528,675 dols., but only 12·9 per cent. in value were carried in American vessels. In the year 1859 the total exports from the United States amounted to 356,789,462 dols., and of this amount 70 per cent. was carried in American vessels and the remainder in foreign vessels. Since then the value of exports from the country in American ships has declined rapidly, until, in 1900, the total exports were worth 1,283,999,941 dols., and of this only 7·1 per cent. was carried in American vessels, the figures for the years 1898 and 1899 having been only 5·9 per cent. and 6·9 per cent. of the total value of the exports so carried.

CHAPTER XVII.

Standard Specifications, Sections, and Tests.

Origin and Economy of Movement for *Standards*.

AMONG the influences that have within recent years tended to bring about a notable economy in the costs of producing, handling, and applying iron and steel in the United States, the system of standardisation holds a conspicuous place. This has been a much easier matter to effectuate in the United States than it has hitherto been in Great Britain; first, because the American manufacturer is not so conservative in his methods and ideas, so isolated in his action, and so subservient to the caprice of inspecting engineers; and next, because the recognised policy of the United States is, and has for many years been, to adopt all systems and suggestions that make for increased economy, whatever trouble, cost, or interference with preconceived ideas and vested interests such changes may involve.

It is not many years since, in the United States, there were almost as many sections for iron and steel as in our own country, more especially in structural shapes. According to information compiled by Mr. H. J. Skelton, there were in 1900 only 32 channel and angle sections in general use there, against 122 in the United Kingdom, and 34 in Germany. Of late years, a great deal of thought and action has been devoted to the pruning of the section book, and the standardisation of such forms as were deemed most suitable and convenient for various requirements.

In the movement which has resulted in reducing the number of sections used in American structural steel practice, the Carnegie Company has taken a prominent part. From Mr. Hoffman, the Philadelphia agent of that company, I obtained a short history of the movement, which, he says, began about 1881, when the company began to roll steel sections instead of the older iron sections, which were found to be wasteful in both material and methods. The company issued blue prints of their steel sections, showing a notable economy both of material and of labour, to architects, shipbuilders, and others interested. An interchange of views and requirements followed. Standard sections of beams, channels, and girders resulted, but for a time the number of sections was increased rather than reduced, owing to the demand for larger dimensions.

The next step in the movement resulted from the action of the

Government of the United States in virtually building a new navy. This led to a demand for a considerable number of sections of angles, deck beams, bulbs, etc., not previously manufactured in the country. It necessarily took some time to find out what sections were best suited to the requirements of the new naval programme. As experience was accumulated on the matter, the manufacturers gradually got the older and less useful sections eliminated. This, however, was not consummated to any material degree until within the last five or six years.

Standard Sections.

As the case now stands, the Carnegie Company, which, in this matter, is recognised as acting for the steel trade generally, stands for simplification of sections as far as possible, and for the avoidance, to the utmost extent, of intermediate sections, which can usually be dispensed with. Buyers are urged to assist as far as possible in cutting weights and sections down to something like a uniform basis. If sections are called for outside of the categories thus limited, the Carnegie Company say, in effect, that they do not supply them.

Obviously, the purpose of this action on the part of the Carnegie Company was that of having any one section applied to as many different purposes as possible, so that a larger tonnage can be got out in each case. In this the company has been successful.

I am told that no formal agreement has been come to by American steel manufacturers as to the number and character of the sections that they are prepared to roll. The reduction of sections, so far as the old section books were concerned, was more or less of a natural evolution. There is not even an understanding that the number of sections must be limited. As a matter of fact, the total number of sections is constantly being added to by introducing new ones for new purposes, but the process of simplification goes on all the same.*

Mr. Hoffman informed me that the American Steel Companies do not, in any case, refuse to roll a particular section which may not be on their section books, but say, in effect, to their customer who may call for a new section: "We don't roll that section, but if you pay for the cost of a set of rolls, and give us a sufficiently large order to make a reasonable run on the section, we will take it up." "The cost of rolls," he added, "is still one of our heaviest items; many sets of rolls cost us more than 3,000 dols."

Standard Specifications.

Within the last two or three years, very great improvements have been made in the standardisation of American specifications for materials of all kinds, including rails, tires, forgings, castings, axles, splice bars, boiler plates, rivets, and structural steel for buildings, bridges and ships. This important work has mainly been brought about by concerted action on the part of the leading steel manufacturers of the United States, who formed a special organisation for that purpose, the

* One of the largest section books is that of the American Hoop Company, for which a new catalogue is now in course of preparation, with the sections brought up to date.

arrangements being left in the hands of my friend, Mr. A. L. Colby, metallurgical engineer of the Bethlehem Steel Company. I asked Mr. Colby to give me a few facts as to the history of this movement, and he has done so in the communication which will be found in the Appendix.*

As regards the materials employed in manufacture, the practice in the United States is to refrain from imposing restrictions on details, it being considered, as stated by Mr. Colby† that "in general, it is outside of the province of the engineer to specify details of metallurgical processes, when he is afforded by the manufacturer every reasonable opportunity to test the finished material." In the case of eight foreign rail specifications, the manufacture is limited to the use of "best English or Spanish hematite pig-iron and charcoal spiegeleisen." Mr. Colby points out that "this unnecessary requirement cannot be complied with in any American rail mill, and, if seriously interpreted, would seriously limit English competition.‡

The American specifications prescribe open-hearth steel only for axles, tires, boiler plates, rivets, and structural steel for bridges and shipbuilding; open-hearth or Bessemer steel for castings, forgings, rails, splice bars, and structural sections for buildings; and open-hearth, Bessemer, or crucible steel for castings and forgings, while for tires only open-hearth and crucible steel are permitted.

Standard Tests.

Drop tests are called for in the specifications for axles, tires and rails, in accordance with general American practice. For fire-box

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* Mr. Colby at the same time sent me the following explanatory letter:—

"BETHLEHEM STEEL COMPANY,
"SOUTH BETHLEHEM, PA.,
"*October 7th*, 1901.

"My dear Sir,—

"As promised during your visit with us to-day . . . . I enclose a brief historical account of the efforts which have been made in this country, since 1895, looking towards the standardisation of specifications for iron and steel, which have led up to the recent adoption, in August last, by the American section of the International Association for Testing Materials of the enclosed *American Standard Specifications*. As stated in my historical introduction, these specifications were not only adopted at the Fourth Annual Meeting of this American Section, held on June 29th, 1901, but were subsequently adopted by a letter ballot of the full membership of the American Section; they are therefore in no wise subject to criticism of being "Manufacturers' Specifications," but are rather a *compromise* between engineers, manufacturers and customers, and as they are the result of numerous Committee meetings held since March 9th, 1899, may be safely accepted as the mature judgment of the American Section of the International Association for Testing Materials.

"Yours truly,
"ALBERT LADD COLBY,
"Metallurgical Engineer."

Mr. J. S. Jeans.
"Shenley Hotel, Pittsburg, Pa."

† *American Standard Specifications for Steel*, 2nd Ed., 1902, p. 14.
‡ *Ibid*, p. 15.

steel there is a test for homogeneity. Percussive tests are only specified for large steel castings. Tests of tensile strength are specified in order to secure that the necessary limits of the quality are present. Yield-point tests are specified because they are believed to "furnish a desirable check on the accuracy of the assumption that the elastic limit of the material under consideration is at least one-half of the tensile strength. Tests for the contraction of area are specified for castings, axles, and forgings," where the tensile strength is determined on a *turned* test specimen. "Cold bending tests are adopted as furnishing a valuable indication of the quality of metal, and quench-bending tests are required for open-hearth, boiler-plate, and rivet steel," to insure the absence of excess of carbon or other hardening element."

The scope and range of this Report do not appear to call for more detailed facts as to standard tests, but the reader who may desire more specific information on the subject, will find it set out in Mr. A. L. Colby's recent valuable work,* where the tests prescribed for all the principal categories of steel products are given at length.

The steel manufacturers have established a "standard specification" for testing, which sets out:—

"The elongation shall be measured on an original length of 8 in., except when the thickness of the finished material is $\frac{5}{16}$ in. or less, in which case the elongation shall be measured in a length equal to 16 times the thickness; and except in rounds of $\frac{5}{8}$ in. or less in diameter, in which case the elongation shall be measured in a length equal to eight times the diameter of section tested."

By this specification, if the test specimen had a thickness of $\frac{5}{16}$ in. or a diameter of $\frac{5}{8}$ in., the elongation would be measured over a length of 5 in., but if the thickness or diameter were a trifle greater, it would be measured over 8 in. It has been pointed out that the liberality of the manufacturers, to themselves, is shown in these specifications in the absence of any requirement as to phosphorus, and also in the provisions that in structural steel only two test pieces shall be taken from each melt or blow, one for tension and one for bending, and in boiler-plate steel only four test pieces are to be taken, two for tension and two for bending.

In April, 1900, the American Chemical Society adopted a series of resolutions for the establishment of a National Standard Bureau, in view of the need of apparatus of guaranteed accuracy in chemical and physical investigations. Hence, the United States Congress has been urged to found such a bureau, in connection with the Office of Standard Weights and Measures, in order to provide facilities for verification of and for stamping chemical-measuring apparatus.

The great variety of specifications hitherto existing in the United States has been regarded as an annoyance and an obstruction. There were recently in existence specifications for boiler plates framed by the British Board of Trade, Lloyds' Register, the American Shipmasters' Association, the American Boiler Makers' Association, the United

* *American Standard Specifications for Steel.* The Chemical Publishing Company, Easton, Pa., 1902.

States Navy Department, the United States Board of Inspectors of Steam Vessels, the Pennsylvania Railroad Company, and many others, together with the specifications of various private testing laboratories and individual engineers.

In a recent article the *Engineer* pointed out that in the present day it is extremely desirable, not only that the cost of work of all kinds should be kept down, but that every facility should be given for its rapid execution. "The head and front of the offending of the modern specification is that it augments cost and hampers production. There can be only one way of accounting for this if it be true—namely, the incompetence of the man who draws the specification. We speak of incompetence advisedly. A man may be a very able engineer, and yet woefully incompetent in his dealings with his fellow-men. Let us take a case in point; very similar things occur every day. A certain railway is being made, say, in one of the colonies. Broadly speaking, the bridge work is of a very ordinary kind. It can be divided up in terms of spans. There are four or five spans of 100 ft. wanted; 50 spans of about 40 ft., and a number of girders to cross very small gullies, little more than culverts. There is no sufficient reason why all the bridges of the same span should not be identical throughout. There are, say, five bridges of 100 ft. each, then all that are needed are ten lattice girders, with the cross girders, etc., for a span of 100 ft., 100 plate girders for 40-ft. spans, and a number of rolled girders of sufficient strength for the gullies or culverts make up the total. A man manufacturing girders or bridges on his own account would keep all the necessary material, and, indeed, many of the parts, in stock, and the purchasers could buy out of stock, and, therefore, in the cheapest and quickest market. But nothing so simple will satisfy the English civil engineer."

Conferences international in character have been held during recent years at Munich, Dresden, Berlin, Vienna, Zurich, Stockholm, and Buda-Pesth, for consideration and determination of the problems involved in testing methods, including the proportion of standard specifications for properties and inspection of materials.

The International Association at a recent date had over 1,600 members. The objects of the association are stated to be the development and unification of standard methods of tests for the determination of those qualities of materials of construction and others which are of technological importance, and the perfection of apparatus for that purpose. More than 120 members of the association are resident in the United States.

The sub-division of the problems dealt with, or set out in the programme of the association, covers a wide range, and includes, besides the establishment of international standard methods of testing and inspecting iron and steel, based on specifications in actual use, the adoption of methods of determining uniformity, and the unification of methods of testing different materials.

In 1894 the American Society of Mechanical Engineers appointed a "Committee on Uniform Standards in Methods of Testing Materials and of Test Specimens," which secured the co-operation of a large number of engineers and engineering laboratories in studying the methods pursued and in making duplicate tests.

Changes in Steel Rail Sections.

The American Society of Civil Engineers has recently had before it a proposal for the appointment of a committee to consider suggested modifications of the American Society rail sections. These sections have been widely adopted, and probably 70 per cent. of all the rails rolled in the United States are now rolled to them. Since that the rolling mills have taken means to finish rails at a lower temperature. It seems to have been found out that the flange of the American Society section is relatively too thin for the best results, perhaps even for succcessful results, in this cooler rolling, while the process of re-rolling worn rails seems likely to become an important element in economy, and it is found that a thicker flange will better fit the rail for re-rolling.

SECTION XI.—SOME ECONOMIC PROBLEMS.

CHAPTER XVIII.

Currency, Credit, Banking and Wealth.

Financial Panics.

NOT a few experienced and practical observers are dissatisfied with the present situation of American finance, and look forward with a certain amount of apprehension to the future. This is partly due to the operations and aggressiveness of the Free Silver Party, partly to the exceptional conditions under which banking is carried on in the country, and partly as the result of what is deemed to be the instability of general credit, which is the almost inevitable outcome of the large risks undertaken, and the dangers attendant on financial panics.

In dealing with the present and the future of so gigantic a national interest as that of the iron and steel industries, which may be taken to represent an aggregate value of not much, if any, less than 400 millions sterling, the influence of currency and banking cannot be overlooked, seeing that financial stability lies at the root of all sound and permanent business. It becomes all the more important, in view of the well-known fact that panics have been more frequent and more acute in the United States than in almost any other country, and that not only is there no security providing against their recurrence, but the liability to financial crises is believed by not a few authorities to be at least as serious, if not even greater than ever.

The financial records of the United States show that in the great panic of 1837-1838 more than 1,000 banks, practically all the banks in the United States, failed. In 1856 nearly every bank in the United States closed its doors and went out of business, and but few of them ever resumed. Again, in the panic of 1873, a great many banks in the United States failed, and in the panics of 1890-1893, all the banks in New York City suspended payment and only certified their customers' cheques.

In the panic of 1893, the medium of exchange was reduced by the action of the national banks in refusing to swap credits, to the extent of more than 300,000,000 dols. A recent writer has remarked that there is no way to tell how a great reduction was produced by the action of the State banks and the trust and other companies which exercise the functions of commercial banks, but that if that reduction was the same as that of the national banks (and there is some evidence that this estimate would be correct) the aggregate reduction of the medium of exchange was not less than 600,000,000 dols.

During this panic, the market value of the products of the farms and the factories was abnormally low, and it was estimated that there were more than 2,000,000 labourers in the United States who were unable to sell their labour at any price, while millions more were compelled to sell their labour at a reduced price.

In 1893, there were 3,830 banks in the United States, with net

deposits amounting to 1910·4 million dols., and a reserve of 380·5 millions. In 1900, the number of banks had increased to 3,595, the net deposits to 3031·5 million dols., and the reserve to 630·8 millions. The capital of all the national banks between 1876 and 1900 had increased from 504·2 million dols. to 602 millions, and the surpluses had increased from 134·4 million dols. to 247·6 millions.

The net earnings of the national banks have fluctuated materially. During the last quarter of a century, the maximum in any single year was 40·1 million dols. for the six months ending March 1st, 1891, and the minimum was 13·6 million dols. for the six months ended September 1st, 1878. Between the first half of 1893, and the first half of 1894, their net earnings fell from 36 millions to 19·7 millions of dols.

Banking Business.

The transaction of the New York Clearing House between 1890 and 1899 varied as under :—

Capital	58·9 to 60·8 million dols.
Clearings	37·6 to 57·3 " "
Balances paid in cash	1,753 to 3,085 " "

It has been an interesting problem for economists in both Great Britain and in the United States to seek to ascertain how this liability to panics, and such serious consequences as their result, have come about, in view of the figures above quoted.* The problem is all the more important that the capital of the banks of the United States is really greater than that of the banks of the United Kingdom, and that no such dire distress has attended financial panics in this country.

Not only so, but American financial authorities have pointed out that† "the loanable medium of exchange produced by the banks of Great Britain was 565 millions sterling, while the loanable medium of exchange produced by the national banks of the United States was only 520 millions sterling. By their superior organisation the banks of Great Britain, with approximately half the capital, produced nearly twice the amount of loanable medium of exchange."

The constitution of the United States (Act I., section 8) gives Congress "the power to coin money, regulate the value thereof, and of foreign coins." Congress has established a gold and a silver dollar, each of a certain weight and fineness, and it can give these coins any value that it pleases.

It appears that one explanation of the liability to financial crises in the United States is that the American laws require certain minimum percentages of reserve, and compel the banks when that percentage is reached to suspend the exercise of the banking function. This provision of the law was intended to be a safeguard, but it has been held that upon several occasions the observance of the law would have brought ruin upon all the banks. On these occasions the New York City banks have boldly disregarded the law in respect to the reserve,

* These figures are abstracted from the *Statistical Abstract of the United States*.

† Address to the bankers of Milwaukee by Mr. Stickney, president of the Chicago and Great Western Railroad Company.

and, in defiance of the law, have stood together for a few days as a system.

The banks of the United States, according to Mr. Stickney, "are not parts of a whole plan connected in such a manner as to create a chain of mutual supports, but they are local and independent institutions. In times of commercial crises each must depend upon itself, and as it is evident that one bank, without the co-operation of the other banks, cannot support the enormous credits of a commercial nation like the United States, each begins to scramble to increase its cash reserve at the expense of the other banks, and to reduce its liabilities."

Cash Reserves.

The currency law of the United States calls for the holding in the United States Treasury of large reserves, which have exceeded 500 millions of dollars, in addition to over 100 millions held in personal and corporate reserves and in silver. It was said by a writer of authority some years ago, that "this great and growing aggregate stands before the world a menace of vast proportions, depressing the price, and retarding the metallic union so much desired."* The exclusive privilege of issuing currency notes, based upon interest-bearing bonds of the Government, as security, is given to banks specially organised, and every other form of circulating note is prohibited under a penalty of 10 per cent. It has been claimed that by this prohibition of currency the annual commercial movement of the United States is obstructed at the vital point of departure, that it causes a want of elasticity and flexibility in the circulating medium, and that, although to some extent this want has been supplied by the increase of small national banks organised throughout the country, by which local exchanges of commodities are pivoted from one dealer to another, as in the country store, by means of deposits and cheques, the redemption of the public debt has practically caused the "National Currency Act" to become ineffective.

The following figures compare the circulation *per capita* and the units of money to units of currency in the United States and eight other leading countries :—

Country.	Circulation *per capita* of leading countries. Dols.	Units of money to units of property.
United States	25·00	1 to 40
Germany	19·50	1 to 33
France	41·50	1 to 27
Austria	9·00	1 to 51
Spain	19·00	1 to 31
Russia	5·00	1 to 42
Holland	28·50	1 to 40
Italy	11·00	1 to 42
Great Britain	20·00	1 to 60

It has been argued that these figures, however statistically interesting, are calculated to mislead, since they appear to show the same *per capita* circulation for countries whose wealth, commerce, and

* George S. Coe on "The Real Currency of Commerce."

general conditions are widely different. Nevertheless, there is probably no better way at present available of indicating the two conditions which the table is intended to illustrate.

Strengthening American Finance.

Various measures have been proposed with a view to the improvement of the financial situation of the United States—among others, free silver and free banking. The opinion of the people of the United States has so far been declared against free silver, on the ground that it carries with it a debased currency, and has asserted that the only sound system is a gold standard, which expresses itself in a currency of unchanging value. What is still required to strengthen American finance is declared by authorities to be "the redemption in gold, and the legal-tender demand obligations of the Treasury to cancel them, and thereafter to refrain from entering into competition with the banks in the field of bank-note issuing." The conferring on the banks of enlarged powers of note-issue on lines of public safety, and making them solely responsible for the redemption of the same in gold, has been advocated, but it has been contended on the other hand that this would place too much power in the hands of the banks. The answer is that while in other countries the banks issue and redeem the promissory notes which circulate as currency, and finance Governmental affairs, without loss to the central authority or prejudice to the rights of the people, the absence of such a system intensifies and widens the disastrous effects of panics in the United States.

Wealth of the United States.

The wealth of the United States is made a matter of ascertainment by the Census of that country, which shows that between 1870 and 1890 the property of the country had increased from 30,000 millions of dollars currency (24,000 millions gold) to 65,000 millions in gold, or an increase within twenty years of 41,000 million dollars gold. I have not yet seen any ascertainment by the Census of the wealth of the country in 1900, but the general belief is that the progress between 1890 and 1900 must have been greater than in any previous decade. Between 1870 and 1890, the savings of the population of the United States amounted to over 40 dols. per annum, and it is a notable statistical fact that in any seven years of this period the average family saved as much as the total sum of its wealth in 1850, and in 16 years had accumulated as much as its total amount in 1870.

American Taxation.

Economists have long claimed that it was one of the most favourable conditions of the United States that it had no standing army worth speaking of,* that it neither had nor required an extensive navy, that its debt was small, and that its necessary outgoings relatively to resources and population were less than those

* The standing army was for many years prior to the Cuban War fixed at 25,000 men.

of any other nation on the face of the earth. All this is now in process of being changed, but so long as it lasted industry naturally enjoyed great advantages in exemption from the heavy and often crushing burdens of European States.

A comparison of the federal expenditure of the last ten years shows that it has during that period advanced by leaps and bounds. Between 1890 and 1900, the total expenditure has advanced from 25 millions to 65 millions of dols. for the navy, from 52 to 235 millions for the army, and from 2 to 23 million dols. for the diplomatic service, etc. The total increase of the expenditure during that period has been 280 million dols., while the total outgoings have increased from 421 millions to 700 millions of dols.

The expenditure *per capita* has within sixteen years increased from 4·15 to 8 dols. annually, being an increase of 92 per cent. In the five years ended 1900, the Federal expenditure rose from 494 to 797 millions of dols., which is an advance of about 61 per cent.

While the total expenditure of the United States for the last three years has been at the rate of about 145 millions sterling a year, this is not so large as that of some European States, and notably Great Britain and France, but it is coming nearer to that level than most American economists would have deemed possible only a few years ago.

Moreover, the expenditure of the United States has almost steadily exceeded the income for a number of years past. The interest-bearing debt has gone up from 41½ million dols. in 1873, and from 64 million dols. in 1891 to 76 million dols. in 1899, while the debt bearing no interest has increased from 538 millions in 1883, and 825 millions in 1890, to 944½ million dols. in 1900.

The United States has dreams of becoming the financial centre of the world, and there are even those who claim that the sceptre has already passed from Lombard Street to Wall Street—that New York is now the dominant city in all matters of currency and finance, and that London must for the future be content to fill a secondary position. This is not yet the case, whatever it may be in the future. The able Finance Minister of Russia on a recent occasion declared that, in his opinion, London still remained, and was likely for some time to continue to remain, the world's principal financial centre. But whether this be so or not is of secondary importance to the fact that the absence of a sound system of banking and more or less unsettled views on currency are liable in the future, as in the past, to precipitate and intensify financial panics, which bring serious discredit on American business methods and stability, and create a sense of insecurity which, until removed, must limit the possibilities of sound industrial and commercial expansion, although apparently interfering but little with the ultimate accumulations of visible wealth. As we have also seen, the increase of national expenditure has recently been such as to justify the belief that American industry is likely to have to bear largely increased taxation in the future.

CHAPTER XIX.

The *Social* *Surroundings* of Workmen.

MUCH of the contentment and prosperity of the typical American workman, as well as his notable readiness to co-operate with his employer in all that makes for the increase of productivity and the cheapening of manufacture, is attributed by some of the largest employers with whom I have had the opportunity of discussing the subject to the fact that the workman is the owner of his own little freehold, and that his domestic surroundings are calculated to make him happy, and to feel a sense of both independence and responsibility. It is certainly the case that most of the working men in the great industries of the eastern and middle States are the owners of their own houses, and that this ownership binds them to the immediate locality by bonds that do not seem to be otherwise equally effective.

This is more or less the case in regard to all the great centres of American industry, but in the cities, as a rule, the workman has to make his own arrangements for becoming his own freeholder, and his purchase of his own dwelling is a matter that he has to carry out unaided. The usual course adopted is to buy a house through one of the numerous building societies that are to be found in most of the large American cities. Philadelphia supplies the most striking example of the magnitude of the business done in this direction. I was informed in that city that the turnover of these societies is nearly, if not fully, equal to that of the regular banks. But in a few cases, the acquisition of his own freehold is made easy for the working man, under conditions of exceptional attractiveness, and nowhere is this so conspicuously the case as at Vandergrift, the head-quarters of the great sheet mills of that name, formerly owned by the Apollo Iron and Steel Company, but now part of the properties acquired and carried on by the American Sheet Steel Company.

As I have for a number of years past devoted a good deal of attention to the economic problems connected with the housing of working men, and as the adequate solution of these problems, in my opinion, lies at the root of better relations between employers and employed in our own country, I have deemed it desirable to say something here of how the plans and arrangements of Mr. McMurtry, the founder of Vandergrift, compare or contrast with those of other capitalists who have aimed at the solution of kindred problems in a more or less similar way.

In Great Britain there have happily been many attempts made at different times by large employers of labour to improve the moral, social, sanitary, and economic conditions of their workpeople. Beginning with the interesting sociological experiments made at New Lanark, by Robert Dale Owen, in the last century, the ideal conditions of labour and the working man's Utopia have been aimed at by such

important employers as the Crossleys, the Akroyds, the Ransomes, the Salts, and many others.

Akroydon.

One of the first of these was the experiment made by Mr. Akroyd, of Halifax, who, to get his workpeople to invest their savings in buying their own houses, set apart, in 1860, a large plot of ground, consisting of 13½ acres, which he divided into building lots, on a uniform plan, prepared for him by an architect. A person desiring to build was required to conform, in regard to the exterior, to the plan drawn by the architect. This was done so as to procure one harmonious style of building throughout the whole of the intended town. Ground for a large square in the centre, and the streets, was given by Mr. Akroyd when the buildings were finished, but a charge was made for the ground on which a house was built. A person intending to build was required to pay a subscription of 15s., which constituted him a member, and, if he desired, the house was commenced immediately. The payment of 15s. per month went on during the time the house was building, and by the time it was finished the member of the society would have paid £10 towards its erection. He had then the option of either paying at once the whole cost of the house, or, in case he was not provided with funds, the building was mortgaged to the Halifax Permanent Benefit Building Society, Mr. Akroyd becoming security to that society for the original deposit money, along with the owner of the house. The mortgage was gradually paid off by monthly instalments, which were in proportion to the value of the house, and at the end of about 12 years the house became the independent property of the member.

Saltaire.

In Great Britain, one of the best known of the model communities founded by the forethought and enterprise of employers, is that which the late Sir Titus Salt established near Bradford, in 1853, for the purpose of carrying on the then comparatively new alpaca industry. I visited this model community in 1873, and wrote an account of it, and of the industry upon which it was founded, with the help of the founder.* On referring to my notes prepared for that occasion, I find it stated that there were then 12 streets running north to south, and 17 running east to west, that they were built of a uniform width, that they open out of one another at right angles, and that the town then contained nearly 900 dwellings, the Census of 1871 showing a population of 4,389. The commonest houses were let at 3s. to 3s. 6d. per week, including rates and taxes, and their accommodation consisted of a front parlour, a sitting-room, and two bedrooms, with conveniences; a better class of house, with three bedrooms, and a garden in front, being let for 5s.

All the houses were built of stone. The erection of beershops or public-houses was prohibited. All the houses are built after much the same model. The institutions embraced the Saltaire Club and Institute, erected at a cost, including fittings, etc., of over £25,000, and embracing a lecture hall capable of seating 800, a lecture theatre to seat 200, a school of art,

* *The Practical Magazine*, Vol. III., 1874, p. 161.

with a valuable collection of models, a gymnasium and drill-hall, and laboratories, reading and recreation rooms, etc. In order to provide for the poor of Saltaire, Sir Titus built 45 almshouses, capable of housing 60 residents, an infirmary, baths and washhouses, a Turkish bath, a Congregational Church with free seats, and a public park extending to 14 acres of land, which embraced provision for boating, bathing, tennis, croquet, etc.

Port Sunlight.

Port Sunlight is situated less than six miles from the centre of Liverpool, so that it is in the vicinity of one of the most populous cities in Europe. The houses are mainly built on the model of Shakespeare's cottage at Stratford-on-Avon. The village was founded about 15 years ago. The streets are laid out somewhat after the style of American cities, with trees planted in the streets and lawns in front of the houses. It is not modern in the sense of some American towns, with electric cars rushing through the streets, and saloons on every corner. The homes of the workmen are modern, and contain the luxuries of bath, hot and cold water, gas, water-closet, etc., —in fact, all scientific sanitary arrangements. Cosy fireplaces are in nearly every room, and all are neatly decorated. All this is included at a monthly rental of from 16s. 6d. to 25s. The rent includes gas and water, and is said to be "scarcely sufficient to keep the houses in repair." Houses of this kind could not be rented at such rates to people not employed in the industry which supports the town, and it has very properly been pointed out that the difference between the stated rentals and such rentals as would pay, over and above repairs, a fair interest on the investment, must be regarded as part of the wages of those who reside in them. The employer and employed together govern the village. There are some twenty departments in the works, and each elects from one to six members of a "village council," the manager of each department being also a representative therein. The village appears to be remarkable for its clubs and social institutions. In fact Mr. Wood states, "the main work of the council appears to be the management and care of these clubs and institutions. To be a member of any club or society costs 1s. a year, the firm adding three times this amount for each person joining, and supplying billiard tables, music, musical instruments, band uniforms, etc." There are public buildings, including a large hall; a pavilion for club meetings; brick school buildings costing £15,000, finished with English oak, and supplied with school furniture made in the United States; and a church which "dates back to the time of Cromwell, and was only saved from destruction by that great reformer turning it into a stable for cavalry." The schools are free, being maintained by the employers.

At Port Sunlight the houses, well-built in quaint Old English style, give a pleasing variety and picturesqueness. The red-tiled irregular roofs, latticed windows, traceries of woodwork, red-brick walls covered with ivy and creepers, and other artistic features, make the little houses as pretty without as they are comfortable within. They are surrounded by well-kept lawns and gardens, while the neat and clean streets are lined with trees. Prizes are given for the best-kept gardens. Only sufficient rent is charged to pay for the maintenance of the houses and

village institutions. If the tenants are reckless and run up repairs, a rise in the rents will follow. The tenants pay their rates direct so as to quicken their interests as citizens. The smallest cottage contains a kitchen-sitting-room, two bedrooms and scullery, and the rent is 2s. 6d. per week. There are stringent regulations limiting or prohibiting lodgers, according to the number in the family. The institutions of the place include a school and a church, institutes for social and educational purposes, a hall used as a restaurant, a concert hall, a post office, co-operative stores managed by the workmen, and a temperance public-house. The other institutions of the place embrace literary and scientific, dramatic, musical, horticultural, photographic and reading societies. The facilities for outdoor recreation and amusement include cricket, bowling, lawn-tennis, cycling, football. There is an open-air swimming bath, a chess club and billiard club, and during the winter smoking concerts, etc. The Port Sunlight death-rate has been reduced to 10 per thousand, while the birth-rate has been as much as 56.

Pullman.

The town of Pullman, on the west shore of Lake Calumet, fourteen miles south of Chicago, I had the opportunity of visiting at the time of the visit of the Iron and Steel Institute to Chicago, in 1890, and again when I visited the World's Fair in 1893. The Census of 1890 showed

FIG. 70.—FOREMEN'S HOUSES, CONNELLSVILLE.

the town to have a population of about 10,600, and it was stated, in 1893, that there were 6,000 hands employed in all the works of the place, whose average earnings were 2 dols. a day. For many years it was claimed that it was "the only town in the world built artistically and scientifically in every respect." The extreme length of the town in 1893 was about two miles in a north and south direction by about half a mile in average width. The general type of the houses is described as the round arched or Romanesque, without the Byzantine details, for chief shops and buildings. The birth-rate was 30 per thousand, while

the death-rate has generally been low. The houses rent at from five to 50 dols. a month, the average being 14 dols. (£2 18s. 4d.) per month, which is stated to be less than the average of similar tenements elsewhere in Chicago—in which Pullman is now incorporated. The ground is owned by the Palace Car Company and by the Pullman Land Association, to the extent of 3,500 acres. The width of the ordinary street is 66 ft., and the distance between house lines is about 100 ft. The main boulevard—111th Street—is 100 ft. wide. The sewage is pumped to a farm three miles south of the town. All the shops and public buildings are heated by steam. The building of Pullman was begun in May, 1880 The water supply is obtained from Lake Michigan and is carried inside all the tenements.

Essen.

In 1895, I had an opportunity of being shown over the "colonies" attached to the Essen Works of Fried. Krupp, in Westphalia, as well as of seeing the more important departments of the works themselves. These "colonies," and the general circumstances of the treatment of their workmen by the Krupp firm, are pretty familiar to those who are

FIG. 71. WORKMEN'S HOUSES, CONNELLSVILLE.

interested in, and have given much attention to, the principles and conditions of model communities. The Krupp enterprise is a sort of paternal despotism. The workman has few rights or privileges that are not liable to be cancelled at the discretion or caprice of his employer. The rents of the houses are no doubt low, and the arrangements made for securing the comfort of the employés are thoughtful, considerate, and, up to a certain point, adequate; but the workman's independence is in no way guaranteed, and he is never without the consciousness that whatever good things may be provided for him are held at the will of his employer. He does not own, and is not afforded

any opportunity of owning, his own freehold. He is not consulted as to the character of the structure which he is to inhabit. He is subjected to a severe discipline as to the conditions under which he is to live, and his control over his own surroundings is little more than nominal. On the other hand, he is afforded opportunities at the Essen stores, which I went over, of purchasing commodities cheaply, his wages are good—for Germany—he is treated with consideration in his old age, and his constant employment is pretty well ensured. The Krupp dwellings, as a rule, are also well built, healthy, with plots of ground attached to the best of them, and let at reasonable rents.

Vandergrift.

In June, 1895, the new town of Vandergrift was begun by the purchase of some 640 acres of farm land by the Apollo Iron and Steel Company, or rather by Mr. George G. McMurtry, its well known head.

When the managers of the Apollo Iron and Steel Company decided to build the new plant, they also decided to lay out a town which would be so superior to the ordinary industrial settlement that it would attract a high class of working men. The financial benefits to accrue from the sale of lots were not overlooked, but this phase of the undertaking was made subordinate instead of paramount. The site selected was ideal. The mills were laid out on a comparatively level part of the tract. The ground set apart for the town slopes up gradually from the Kisiminetas River, affording perfect conditions for drainage. The services of Frederick Law Olmsted, the famous landscape gardener, were secured in making the plan of the town. He laid out wide streets, not crossing each other at right angles, but forming arcs of a circle gently curving with the contour of the ground. The plan provided for a number of small plots to be ornamented with flower beds or shrubbery. Thus the beginning was made for artistic effect, which seems to have been deeply impressed on the minds and habits of the people. The lots as laid out were of good proportions, with an alley running through the centre of every block. A complete system of sewerage was installed, pipes were laid for gas and water, connections were run to every lot to prevent the streets from again being torn up, and the streets and alleys were then paved handsomely and durably with vitrified brick. It was intended from the beginning that the town should have no outhouses.

At the outset the men who were desirous of securing employment in the mills had the first opportunity afforded them to purchase building lots. The price was fixed at the average of five years for areas of similar extent in Apollo—a neighbouring town. No stipulations were laid down as to the frontage or character of the house to be built, every man having liberty to follow his own taste. One of the unique features of the town is that the land company—which was made an entirely separate concern, and is not associated, except indirectly, with the manufacturing company—did not, as in most other similar cases, build houses to sell or let, nor did they undertake

Fig. 72. Workmen's Houses in Grant Avenue, Vandergrift.

the building or the running of any shops or stores. They certainly did provide for and control gas, water, and electric light, but it was one of the principles laid down by the founder that the owners of the real estate should not in any way compete with private enterprise, where it could be avoided. And this principle, which has been strictly adhered to, was to assist the workmen, as far as possible, to assist themselves, but always with the conditions and appearance of having their absolute independence of action unaffected. Thus the men in all cases have been responsible for the design and arrangement of their own houses, they have bought the freehold of the land on which their houses are erected, and they are not interfered with in any way in municipal affairs.

Vandergrift has been incorporated as a borough under the laws of Pennsylvania, its present population being about 6,000. All public improvements, the building and control of schools, the building of churches, the organisation of public entertainments, and other purely local and social affairs are carried out by officials or bodies elected by popular vote.

Being situated in a district which is rich in natural gas supplies, this popular form of fuel is used in every house for heating and lighting, its average annual cost being from 30 to 40 dols. per house, while the cost of living in other respects may roughly be indicated by the fact that the average payment per annum for rates and taxes is 33·75 dols, and for water 12·75 dols.

A recent description* of Vandergrift states that "the aim of the builders of Vandergrift was to attract a high class of working men. This they have succeeded in doing. It is, however, a remarkable settlement of young people. It is believed that in it hardly a dozen persons can be found over 50 years of age. The skilled men employed in the mills, from superintendents down, will not average over 32. This has not been brought about by any forced arrangement, but probably demonstrates that young men are more likely to settle in a new locality than old ones. Further, the working men are largely natives of the locality, sons of farmers or of working men in near-by towns. It is believed that not over 10 per cent. are foreigners, and these are principally employed in the galvanizing department, where the character of the work is distasteful to men fitted for a more skilled vocation. Among such a high class of workmen a general spirit of good fellowship is shown. They freely and willingly assist one another, their intercourse being remarkably free from discord. Here the influence of the management and the power of a good example are seen. It is a cardinal principle in the Vandergrift Works that every man shall be treated as a man, whatever his station may be. If a roller has a difference with a scrap-boy, the superintendent gives a hearing to both, and if the scrap-boy has been unjustly treated, the roller is compelled to make amends. Any man having a grievance is invited to make it known to the management, and if on investigation the complaint proves to be well founded, the trouble is corrected. All superintendents, to the highest, know the men personally, so as to be

* *Iron Age*, Nov. 21, 1901.

able to call them by name and take pains to speak to them. Thus a bond of friendship and mutual interest is created and sustained."

Accompanied by Mr. Pargny, the general manager, and my colleague, Mr. Parkes, M.P., I visited several of the houses at Vandergrift, beginning with the aristocratic mansion of a roller, who was in receipt of about 13 dols. per day, and finishing with the unpretentious house of a workman employed as timekeeper, at 2½ dols. In the roller's house these was an oak staircase, an up-to-date piano, a number of really excellent pictures, a roomy and elegant hall, and a general air of style and gentility. The domicile at the other end of the scale, was more like that of a respectable working man at home, clean and neat, and bearing evidence that there was no superfluous wealth about. But all alike signified in the most unmistakable way that the residents of Vandergrift felt and acted up to the influence of their surroundings—that having no squalid, ugly, and demoralising exterior conditions, they felt it incumbent on them to keep their interiors as decent as possible, although in cases where there are large families this may not always be easy. It was clear also that both men and women were proud of the place, and had pleasure in showing how tidily they kept their several homes. The element of tidiness is omnipresent, and it is nowhere more in evidence than in the appearance of the children, who are almost always dressed with a degree of taste and neatness that is too often absent in British homes. Cleanliness is guaranteed by the fact that every house has its own bathroom and other up-to-date sanitary conveniences.

One of the features of Vandergrift that must immediately strike the visitor, and in respect of which it differs from almost every other working man's colony I have seen, is the individuality of the houses. There are, indeed, one or two terraces built on a symmetrical plan, but apart from these there has been but little care to maintain uniformity. More or less, every workman has been his own architect, and has adopted his own ideas of style and arrangement. This tends to create a "house-proud" feeling on the part of both men and women, and comparisons of architectural conditions and characteristics are naturally common among the proprietors of these often chaste and elegant abodes. The cost of the houses range from 600 or 700 to 1,400 or 1,600 dols., and the workmen are largely helped in their financial arrangements by a local building society, which is usually ready to lend whatever may be needed at a moderate rate of interest. Vandergrift, if not the only "working man's Paradise" in the New World, is at least the nearest approach to the ideal, both in its physical conditions and its construction, of any place that I have ever seen in the course of pretty extensive wanderings, both in the Old World and in the New.

It would be unpardonable in any notice of Vandergrift to omit due notice of its founder—its "guide, counsellor, and friend," since its inception. This distinguished position belongs to my friend of many years' standing, Mr. George G. McMurtry, who is now the president of the American Sheet Steel Corporation. In a great speech delivered in 1826, on the relations between Great Britain and Portugal, George Canning declared: "I called the new world into existence to redress

the balance of the old." Mr. McMurtry has called a new community into existence of which he is justly proud, partly to redress the balance of the old community at Apollo, but mainly to prove—as he has done with most signal success—that working men who are happy, and contented, and independent, and treated with respect, are not so liable to take false and short views of the economic bases of the industrial system as men who know but little of these things.

I do not, however, wish or intend to convey the impression that there are many Vandergrifts even in the most desirable and enterprising localities of the United States. I do not even intend to imply that American workmen are, as a rule, better housed than those in the old country. Probably, as a rule, they are nothing of the kind. I visited some of the dwellings of some of the men employed about Birmingham, Alabama, by the Tennessee Coal, Iron and Railroad Company, which I select because they were described to me as typical of the workmen's houses throughout that region. I have also visited the dwellings of miners and ironworkers in the North of England, Scotland, Wales, and other localities. In point of comfort the British workman was unquestionably the better off. The American workman has often to make shift with exceedingly poor accommodation—indeed, generally, as it seems to me, outside of the large cities, which is probably, in large measure, due to the rapid rate at which industrial plants are organised. About British industrial centres there is generally more pains taken to secure the element of stability, workmen's dwellings included.

CHAPTER XX.

American Products in Foreign Markets.

Principles and Profits.

THE fact that the United States have greatly increased their exports of iron and steel products within recent years, is not necessarily a proof that they are in a position to continue to do so under a free fighting trade. It is unquestionable that the tariff has greatly helped the recent increase of exports. Nor is the fact that the United States can produce steel more cheaply than any other country necessarily a proof that they can capture foreign markets on a large scale. These two facts appear to control the whole situation, but there is a third that appears to me to be almost equally fundamental—namely, the fact that prices and production are subject to such a phenomenal range of fluctuation that the so-called "invasion" of to-day may be turned to a regular rout to-morrow. In other words, there does not at present appear to be any solid guarantee of stability in the American exports of iron and steel—first, because there is no assurance that the tariff will be maintained; secondly, because without the tariff American manufacturers could not rely on exporting with profits; and thirdly, because the trade of the United States, as at present constituted, is likely to be intermittent and irregular, and no trade can be so well founded as that which is least liable to extremes of value and of volume.

To a large extent, the principles on which the export trade of the United States is at present founded were laid down seven years ago, in an editorial in the *Iron Age* which said:—

> "It is likely that our manufacturers will have to treat the foreign markets, in many cases, as the slaughtering-ground for a surplus, or as a means of reducing cost by enlarging business, and thus running up to full capacity. In doing so they will merely follow the example of producers in competing countries who have frequently used this very method to capture trade in this country."

Everyone who knows anything of the subject is aware that this has largely been the course followed in the export trade done by the United States, up to the present time. I do not say that no materials have been exported at a profit. Possibly, indeed, a profit, although not an adequate one under all the circumstances, has attached to the great bulk of the materials shipped to Europe. But that was during a period of exceptionally low costs. No American products in iron and steel can be sent to Europe with a profit at the average quoted prices of 1900-1901, and the extent of the future invasion of European markets by such products must largely depend on how far and how long those prices are likely to be maintained. So long as American pig-iron makers can in their home market command, as they now do, from 18s. to 25s. per ton more than the prices quoted in Europe, and from 30s. to 40s. per ton more for finished products, plus railway rates to the seaboard, and ocean freight to Europe, Europe need not be much afraid.

By the time that the older and probably more normal range of prices has been re-established much may have happened, the nature and effect of which, in view of the Stygian darkness that has always enveloped the future of the iron trade, it would be hazardous to predict.

In considering the natural conditions at the command of the United States for the development of an export trade, it is not likely to be overlooked that in that country there are only two steel plants on tide water—one at Sparrows Point, Baltimore, and the other near Wilmington, Delaware. The ore for these plants is brought long distances over-sea. During the last three years much of it has been obtained from Canada, and some of it from Cuba. Neither of these concerns has bituminous coal within 200 miles of its furnaces. The principal group of works that have hitherto done the bulk of the export trade, in finished products especially, is in the Pittsburg district, nearly 500 miles from New York, which is their principal shipping port, although Birmingham, Ala., which is looking forward to the development of an export trade in finished products, as well as in pig-iron, is little more than half that distance from ports that are likely to have a future. Meanwhile, at these southern ports, the command of tonnage is uncertain and precarious.

Anticipation and Realisation.

Writing in 1891, Sir Lowthian Bell stated that "I think it very improbable that, beginning with pig-iron at 53s. per ton at Pittsburg, and adding 8s. 4d. for carriage to a seaport, the older seats of the American iron trade can compete with Great Britain, except to countries close at hand, such as Canada, and the northern portion of South America. If we are to meet American iron in Europe, Asia, or Australia, it will be that produced in the southern States of the Union." The writer of these lines, although proved unreliable as a prophet by subsequent events, was not the only one who failed in 1890 to see the "coming events cast their shadows before." In the twelve years ended with, and including 1890, the imports of iron and steel into the United States, nearly wholly from Great Britain, averaged nearly 900,000 tons a year, mostly in the form of rails, tinplates, pig-iron, and scrap. In the ten following years, the American imports of iron and steel have not averaged more than 300,000 tons a year, and, if we except tinplates, they have not of late years reached 150,000 tons a year, including spiegeleisen and ferro, which are the next most important imports.

Less than ten years after Sir Lowthian Bell had discredited the probability of exports of Pittsburg iron and steel to Europe, the United States had exported to all countries, and largely to the Continent, 1,154,270 tons of iron and steel in one year, which, with the concurrent exports of machinery, hardware, and tools, made up a total value of 130,000,000 dols., or nearly £27,000,000 sterling, and the exports of these commodities had more than doubled in value between 1897 and 1900.

In considering the future of the export trade of the United States, it is important to remember that at the present time no district in the country can export finished or semi-finished materials at a less cost than 2 dols., or 8s. 4d. per ton, for railroad transport alone. That rate is quoted for the railway transport of blooms, billets, and bars. Indeed

the lowest regular rate quoted to-day from Pittsburg to the sea is 2 dols. 10 cents to Baltimore, and to New York the rate is 2 dols. 40 cents, or 10s. per ton. Birmingham, Ala., though much nearer to tide-water, is hardly better off in respect to the rates quoted for manufactured steel. The rate for blooms, billets, and bars to Mobile and Pensacola is 2 dols. 50 cents, or 10s. 5d. per ton, although by going to Savannah or Charleston, which are nearly 200 miles farther, the steel manufacturers of Alabama, somewhat curiously, get off with 1 dol. 75 cents, or 7s. 3½d.

The question that is presented for the consideration of those who are studying the problems that environ the present and the future of American exports, seems to be: How long can the United States continue to pay 7s. 6d. to 11s. 6d. per ton for the railroad transport of iron and steel from works to the sea, plus ocean freights, and still make a profit on foreign trade? So far as I can judge of the facts, the present position of the Pittsburg manufacturers in cultivating European business will be approximately as follows:—

Estimated Normal Cost of Pittsburg Iron in Great Britain.

	s.	d.
Iron ore, per ton of pig-iron	24	6
Coke " " "	11	0
Limestone " " "	0	1
Labour " " "	2	0
Sundries " " "	1	6
Total	39	1
Add freight to seaboard, say	8	6
" Sea transport, say	9	0
" Freight from Liverpool to industrial centres of United Kingdom, say	3	0
Total cost delivered	59	7

According to this showing, British manufacturers are at present protected against the so-called American invasion by the last three items, which collectively make up a sum of 20s. 6d. I speak only of existing conditions. What may happen in the future no one can say. The sea freight is assumed to be a typical and normal one, and is probably rather under than over the average. The freight from British ports to British works is purely hypothetical. Seeing, however, that much of the imports of American steel has been used at Sheffield, South Staffordshire, and other inland centres, it is hardly likely to be too high. Indeed, I am informed by my friend, Mr. Ford, of Youngstown, that he is charged by British railways 7s. to 8s. for carrying iron from Liverpool to Sheffield, which is more than twice the figure I have assumed as the average charge from ports to works. On the other hand, there are ports nearer to the manufacturing centres than Liverpool, although not so likely to be used by the ordinary American tramp.

The Cultivation of Foreign Markets.

Our American cousins did not allow the grass to grow under their feet in seeking for foreign markets, directly they had got to

the level when that process appeared to promise satisfactory results For a century and a half, as history shows,* the United States had exported small quantities of iron to England, but practically the serious business of doing so did not begin until 1896, when the total value of exports under the heads of iron and steel increased by nearly £2,000,000 sterling compared with 1895. In the year 1895 some enterprising manufacturers made a bold bid for certain European markets, but they were sharply taken to task for doing so, the *Iron Age* remarking that:—

"If we can meet foreign producers in distant markets, why should we demand that our home trade be guarded against their invasions? . . . The export shipments in a number of lines are proof of widespread distress rather than evidence of ability to compete under normal conditions. We hold that the low level of prices which has prevailed during the past year is abnormal, and that as soon as we have returned to a condition of moderate prosperity all talk of exports will vanish until the next great drop in values brings us to a basis when a permanent and profitable foothold can be obtained abroad. That time has not yet come. We are manufacturing so very cheaply now because every item of cost is squeezed down to the lowest notch; because, until lately, raw materials were unduly low; freights are now down to an unremunerative basis, supplies are too cheap, wages all along the line are far below the American standard, and profits to capital are generally conspicuous by their absence. If export business is to be obtained at the price of such suffering, American manufacturers do not want it, and will rejoice when the day comes when returning prosperity at home will cut us off from it."

Home prosperity has returned now for three years past or more, but the exports of iron and steel, until last year, showed a steady increase in spite of that fact, and culminated in a total value of over 26 millions sterling, including machinery, in the year 1900.

The English newspapers have sometimes published statements which were calculated to convey the impression that the American iron trade had already gone far to extinguish that of Great Britain, and that American machinery was now supreme, or immediately likely to become so. It is, in my opinion, desirable and necessary that these erroneous impressions should be dissipated by a reference to the solid facts of the case. The average annual exports of iron and steel and machinery for the two countries over the last five years have been as under:—

Average Annual Exports of Iron, Steel, Machinery, etc.

	Great Britain.	United States.
	£	£
Iron and steel	26,100,000	... 9,999,000
Machinery	16,980,000	... 8,520,000
Cutlery	2,080,000	... Included above
Cycles	1,100,000	... Included above
Tools, implements, instruments and apparatus	1,780,000	... Included above
Totals	48,040,000	... 18,519,000

These figures seem to me to make it pretty evident that the United States are still a long way from having come alongside, to say nothing of having wrested the supreme position from, Great Britain. It may be said that Great Britain had a considerable boom during these five years, but that probably made it all the more easy for the United States to encroach upon her markets. It may further be said that the United

* Especially Scrivenor's *History of the Iron Trade*, and Swank's *Iron in all Ages*.

States were not ready five years ago in the matter of price, but eight years ago the average price of Bessemer pig-iron in Pittsburg over the whole year was 11·38 dols. (47s. 5d.) per ton, and it was sold by such concerns as the Carnegie Company for materially less. Moreover, in that year, the average price of both billets and rails at Pittsburg was less than the average of any subsequent years except 1897 and 1898.

While these figures make it clear that the United States have not invaded all the markets of Great Britain with the destructive and invincible influence which some British journals would have us believe, their progress of late years has been truly phenomenal, as the following diagram of their imports and exports will make clear:—

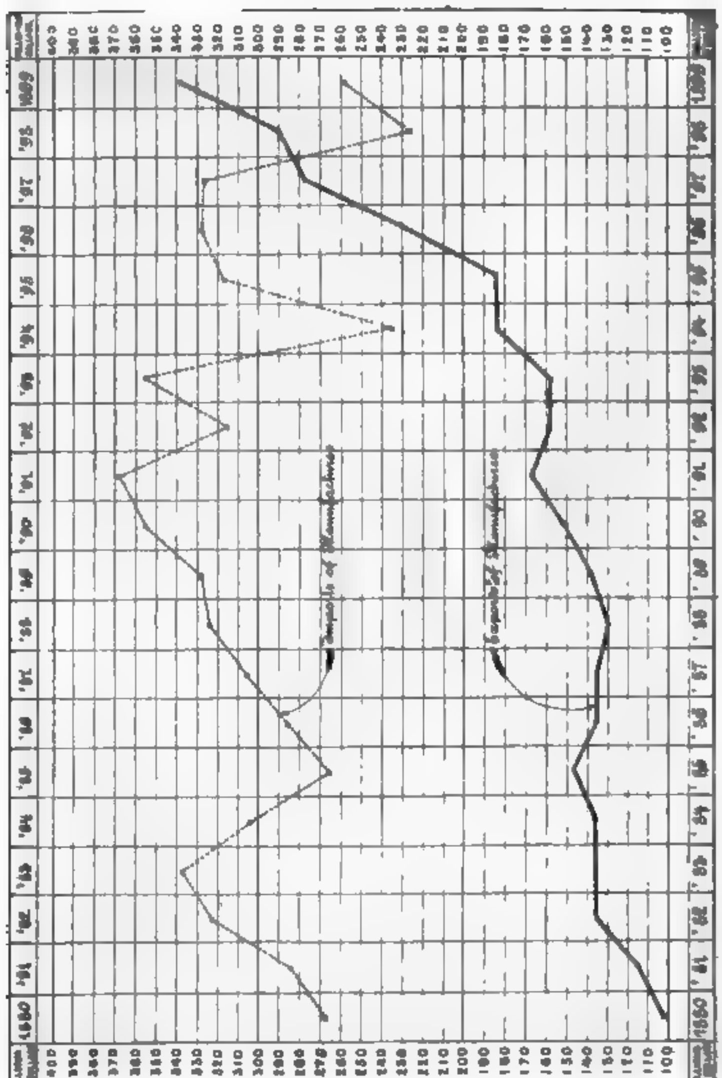


FIG. 73.—DIAGRAM ILLUSTRATING THE IMPORTS AND EXPORTS OF THE UNITED STATES.

The figures published by the Federal Bureau of Statistics show that the total exports of 1900 were four times as great as in 1860, but in domestic manufactures they were nearly eleven times as great, *i.e.*, 432,284,366 dols., against 40,345,892 dols. Taking the last decade alone, the exports of manufactures are equally striking. In 1891 the total exports of domestic merchandise were 872,270,283 dols., while those of domestic manufactures were 168,927,315 dols.; thus, while the total exports for 1900 were but 57 per cent. in excess of 1891, the exports of domestic manufactures were 156 per cent. greater. In all of the foregoing calculations, no account is taken of foreign goods, dutiable and free of duty, re-exported amounting in 1900 to 23,710,213 dols.

Institutions for the Promotion of Trade.

Among the various institutions founded for the cultivation of foreign markets, prominence may be given to the Philadelphia Commercial Museum, which is a unique institution of its kind, having been founded by the municipality of that enterprising city with a view to increasing the knowledge of industrial products and thereby assisting both home and foreign trade. I visited the museum, was shown over it by the assistant director, and was given certain information as to its methods and operations. Its special features are a bureau of commercial information, where information is given as to foreign markets, among other subjects; and technical laboratories, where commercial products are tested and analysed free of charge, unless the tests and analyses are specially costly. In this it struck me that the museum authorities are taking up a position which it is difficult to justify. I was told, for example, that fibres are tested without charge, but that assay of ores has to be paid for. The bureau of commercial information is stated to be self-supporting. Mr. Sell, of *Commercial Intelligence*, impressed with the useful work done by the bureau, has established a similar institution in London, so that whatever advantages such a system can confer are already at the disposal of British traders.

The Philadelphia Commercial Museum has held two Pan-American Congresses, in 1897 and in 1899, which were attended by delegates from most of the commercial countries of the world, including our own.

Membership of the Commercial Museum involves a payment of 100 dols. a year. The bureau employs about 75 officials and the museum about 100. The latter are chiefly employed in forming, placing out, and otherwise dealing with collections of commercial products generally. I should add that in conversations with prominent citizens of Philadelphia, I heard the utility of the Commercial Museum questioned, and some of them even appeared to look upon it as a white elephant. The International Congresses of Commercial Men, which the museum has organised, look well on paper, but I am not satisfied that they have been of material practical value.

The National Association of Manufacturers of the United States is another organisation, established in 1895, to promote the interests of its clients in both home and foreign markets. I visited the offices of this institution in Philadelphia, and was presented by Mr. Sanborn,

as secretary, with a mass of publications—mostly of considerable value —which it has issued from time to time. These publications included a most useful *American Trade Index*, of which editions in English, Spanish, and French have been issued, and in which details are given of the businesses of a large proportion of the leading manufacturers. The association carries on a freight bureau in New York City, in which attention is given to the details of foreign shipments on a co operative, and therefore economical, basis. The matters which this organisation has dealt with include a uniform freight classification, commercial reciprocity, improvement of the consular service, a bulletin containing specific inquiries from foreign merchants who may want to do business in the United States, sample warehouses, etc. Only manufacturers are eligible for membership, and the annual subscription is 50 dols. (£10 8s. 4d.). The association has secured a more or less important footing in all the principal States, and has appointed in each State a vice-president, who is understood to represent its interests.

The New York Merchants' Association.

In many cities and districts of the United States, there are merchants' or traders' associations in addition to Chambers of Commerce, who make it their business to look after such matters as transportation, harbour improvement, Customs' service, taxation, postal facilities, internal trade and foreign commerce. With the executive of one such body—the Merchants' Association of New York—we had the privilege of a formal interview in that city, during which such questions as the comparative conditions of railroad rates and facilities, canal competition, ocean freights, and dock charges were discussed. We found the Merchants' Association of New York to be a very active and even somewhat aggressive body. It regularly publishes a *Bulletin*, and is imbued with a deep sense of the importance of securing cheap transport and ample shipping facilities as the fundamental bases of foreign commerce. In view of the neglected condition of our British canal system, it may be added that this Association has for years agitated for the widening and deepening of the canals in New York State, so as to give direct water communication from Chicago and Pittsburg to the sea.

CHAPTER XXI.

The Tariff System of the United States.

THE trade relations of Great Britain and the United States must be in the future, as they have been in the past, more or less affected by tariff legislation. There are even those who believe that this is the main influence affecting those relations. However this may be, it will hardly be disputed that a consideration of the outlook from a tariff standpoint cannot well be omitted from a general report on the industrial conditions of the United States.

The subject may be considered under the following heads:—

1.—The Tariff Legislation of the Past.
2.—The Outlook for the Future, and its Bearing on the Trade Relations of the Two Countries.
3.—The Reciprocity Movement.
4.—The Free Trade Movement.
5.—Collateral Phases of the Tariff Question.

1.—Tariffs of the Past.

Since the year 1789, when, on the recommendation of Hamilton, one of the first protective tariffs was adopted, the United States have passed more than 20 Tariff Acts. For 113 years, therefore, American statesmen have urged the principle of protection to native infant industries.

When an American is asked to justify tariff legislation, he probably begins with the growth of manufactures from 1850 to 1900, during which period the values of the products of American industries, apart from agriculture, have increased fifteen-fold, and he will be likely to clinch his arguments and his statistics of progress under protection, by pointing to the recent triumphs of American manufactures in outside markets. He may especially note the advances in the exports of iron and steel, which during five recent years showed a gain of 280 per cent., or, in other words, rose from £6,400,000 to the remarkable figure of over 26 millions sterling, as already stated.

The iron and steel industries of the United States have for many years past fought the battle of protection against modified tariffs or free trade through their Association, which is largely kept alive for that purpose. While this organisation lasts, it may be taken for granted that no general free trade measure will ever be adopted by Congress without a great and influential resistance. It has been the business of the *Bulletin* of that Association to disseminate protectionist literature, and to supply arguments and facts for protectionist speakers, throughout the whole of the United States. Other organisations, less directly connected with iron and steel, support the same platform, and in their several ways exercise considerable influence in keeping the community well grounded in the protectionist faith.

The conditions under which, and the range within which, the American tariff of to-day is permitted to operate, are very different from those of twenty, or even of ten years ago. Up to 1890, the United States had to depend, more or less, upon this country for a large part of its supplies of iron and steel. Our exports thither fluctuated very greatly, it is true, but the average over a period of twenty years exceeded 400,000 tons a year, and the American demand was, to a large extent, the regulating factor of our export trade. This led the free trade party in the United States to assume that the American people were paying for their supplies of iron and steel generally at least as much as the amount of the import duties in excess of what they would have had to pay under a system of free imports. The inference, of course, was that a free trade system would have admitted the products of other countries, directly prices exceeded those quoted in Europe, plus Atlantic freight rates. The remarkable fall of prices that took place about 1894 has put a new complexion on this aspect of the tariff. Prices are no longer systematically higher in the United States than in Europe, and, in any case, Europe could not to-day adequately supply the wants of the United States in addition to their own, even if free trade left American markets at the feet of European manufacturers.*

It is no part of the business of this Report to record a general history of the tariffs of the United States. It may, however, be pointed out briefly that of the total imports of foreign merchandise into that country, the lowest percentage that was admitted free of duty, since 1863, was 26 per cent. in 1874, and the highest was 59 per cent. in 1894, so that at the later period the quantity admitted free of duty was considerably more than double that so admitted at the earlier. In the year 1899, the average *ad val.* rates of duty on the articles subject to duty was 50·21 per cent., and the average *ad val.* rate of duty on both free and dutiable articles was 29·48 per cent.

It is noticeable that over the same period the duty collected *per capita* has been as much as 4·43 dols. in a single year, and as low as 1·90 dols., while over the same period the average value of the imports *per capita* has varied from a maximum of 15·91 dols. to a minimum of 7·89 dols.

2.—The Present Situation and Outlook.

It is perhaps hardly in the nature of things that American and British manufacturers should take the same views as to tariff legislation. It is natural that the American should think and speak well of a system under which—if not, as he generally believes, also by which—he has been enabled to enjoy great prosperity, and to establish a large measure of control, not only over his own markets, but also over those of the rest of the world. On the other hand, the Englishman has, for two generations at least, been taught to regard free trade as the only system suited to the special circumstances of his country, and under

* This observation is founded on the fact that in the last two years the consumption of the United States has been nearly 16,000,000 tons of pig-iron annually, which is equal to two-thirds of the total European output.

free trade, if not in consequence of its adoption, British influence, wealth, population, and prosperity have greatly advanced in the last half-century.

This distinction appears to be necessary because there is a tendency on the part of both Americans and Englishmen to regard their own economic system as the only one founded on reason and sound results. It is natural that each should criticise the other's system with a pronounced leaning towards his own, and if I have seemed in doing this to have strained a point against protection I hope that my American friends will not think I have done so consciously or unfairly.

3.—The Reciprocity Movement.

The future trade relations of Great Britain and the United States may be, and some are sanguine enough to believe will be, affected by the extent to which the latter country pursues the system of reciprocity, of which a number of leading economists and manufacturers are declared adherents. But I do not find a great deal of sanction for this belief. It is true that the recent *impasse* which caused Russia to levy differential duties against the United States, has provoked much comment and not a little adverse criticism,* but so recently as December last the National Reciprocity Convention of the United States recommended to Congress the maintenance of the principle of protection for the home market, and refused to sanction reciprocity "except where it can be done without injury to any of our home interests of home manufacturing, commerce, or farming," which appears to mean that we shall see no reciprocity " worth a cent."

The last public address of the late President McKinley appears to have inspired free traders with the idea that he was ready to recant his protectionist creed, and that, had he lived, he would have urged reciprocity on a large scale. It is worth while putting this remarkable and much-debated utterance on record. It was as under:—

"By sensible trade arrangements, which will not interrupt our home production, we shall extend the outlets for our increasing surplus. A system which provides a mutual exchange of commodities is manifestly essential to the healthful growth of our export trade. We must not repose in fancied security that we can forever sell everything and buy little or nothing. If such a thing were possible, it would not be best for us or for those with whom we deal. We should take from our customers such of their products as we can use without harm to our industries and labour. Reciprocity is the natural outgrowth of our wonderful industrial development under the domestic policy now firmly established. What we produce beyond our domestic consumption must have a vent abroad. The excess must be relieved through a foreign outlet, and we should sell wherever we can, and buy wherever the buying will enlarge our sales and productions, and thereby make a greater demand for home abour.

"The days of exclusiveness are past. The expansion of our trade and commerce is the pressing problem. Commercial wars are unprofitable. Our policy of goodwill and friendly trade relations will prevent reprisals. Reciprocity treaties are in harmony with the spirit of the times. Measures of retaliation are not. If, perchance, some of our tariffs are no longer needed for revenue, or to encourage and protect our industries at home, why should they not be employed to extend and promote our

* In the early part of 1901, the United States Treasury Department issued an order affecting Russian sugar, on the ground that Russia pays an export bounty, and Russia retal ated by imposing additional duties on certain descriptions of American iron and steel, etc.

markets abroad? Then, too, we have inadequate steamship service. New lines of steamers have already been put in commission between the Pacific coast ports of the United States and those on the western coasts of Mexico and Central America. These should be followed up with direct steamship lines between the eastern coast of the United States and South American ports."

On the other hand, there appears to be good reason for believing that President Roosevelt has a deep sense of the importance of making use of reciprocity, where it can be used with effect, for the purpose of securing advantages for American trade, and that he is the more inclined to this policy that most American industries are now strong enough to take care of themselves. When I was in Washington in 1901, it was announced that "the importance of the early ratification of the pending treaties and the negotiation of others is emphasised by reports which are now reaching the State Department through diplomatic channels concerning the negotiations now on foot between various European countries looking to the drafting of commercial conventions to take the place of those which expire within the next year or two. . . . . The tariffs and certain commercial treaties of Germany, Austria and Italy will expire in 1903, and arrangements are already being made looking to the renewal or modification of many of these treaties. It is anticipated that during the next twelve months all the necessary negotiations will be completed, and the Administration feels that unless the interests of American manufactures are provided for by favourable reciprocal trade arrangements within that length of time we (the United States) shall find our foreign markets greatly restricted."

4.—The Free Trade Movement in the United States.

My old friend, Mr. Abram S. Hewitt (with whom I have had the advantage of several discussions on this subject, and whom I was pleased, in October last, to meet in New York, wearing lightly his eighty years of busy and useful life), in the House of Representatives, in 1882, as the honoured member for that city, made a speech which was almost prophetic on the subject of American protection *versus* free trade. He declared that the transition in the United States from protection to free trade "may be made gradually and naturally, but if we continue to dam up the stream of progress it may come accompanied by a convulsion that will shatter the very framework of our society; and," he added, "the primacy of industry will be transferred from the old world to the new, and this without impairing our ability to pay the higher rate of wages due to cheaper food, lower taxes, and greater personal intelligence in work."

No one who has given attention to the issues of tariff controversy can fail to be struck with the many fallacies that have been permitted to obscure and pervert the fundamental facts of the subject, both in Europe and in America. A writer of some repute stated, in 1878, that "so long as the United States adhere to a strictly protectionist tariff we (in England) are safe." Is this really so to-day? He added that "we are not likely to be superseded in an open market, so long as American industry is shackled by protection so effectually as it is now!"* Again,

* James Henderson in the *Contemporary Review*, October, 1878.

in 1890, Lord Playfair, who enjoyed a considerable reputation as an economist, declared that "the party of protection is not yet destroyed, but it will fight in future with furled flags, while the Democrats will consolidate their party upon the foundation of a tariff for revenue and not for protection!"* In the twelve years' interval that has since elapsed, the free traders of America can hardly be said to have had much of an innings.

There has, however, always been an influential party in the United States in favour of free trade. It cannot truthfully be said that the party has been a relatively large one. Nevertheless, it has kept alive the belief in, and the advocacy of, the principles on which free trade is founded. That party is probably as much in evidence to-day as it ever has been, to judge from the testimony made by its representatives before the Industrial Commission now sitting.

The free trade party has recently received an accession of strength from the action of New England manufacturers, who complain of the fact that they are placed at a disadvantage by the present duties on pig-iron, billets, etc., which are the raw materials of their industries.

One of the largest manufacturing concerns in Bridgeport, Conn., sent to the Press, in May, 1901, a communication which pointed out that the manufacturing associations in the various cities along the Atlantic seaboard and Canadian border, and especially in New England, were complaining of their handicap in the cost of raw material, such as coal, coke, iron ore, pig-iron, steel ingots, and billets, and had expressed their desire to have these commodities placed by Congress immediately upon the free list. "They believe that as these materials are produced cheaper in this country than in any other portion of the world, and are sold abroad at lower prices than along the seaboard and Canadian border, the industries which produce them are no longer infant, and do not need protection. They believe that protection, so called, is but another term for Government assistance to monopolies and trusts. This position the Government, as it now exists, can ill afford to assume, nor can it allow the people to feel that it is drifting into such a position, where it is working hand in hand with gigantic trusts; for when the people realise this to be the condition of affairs they will undoubtedly arise in their might, and by their votes change the conditions and the Government which permits such conditions.

"It is reasoned by the various manufacturers that as industries cease to be in a position where, with the cheaper labour, European manufacturers can threaten them, protecting duties should be removed on the score that they are no longer infant industries which need nursing.

"In this way the many manufacturing interests using coal and coke and iron and steel, both cast and wrought, will be assisted, especially in this district, which has indirectly been taxed for the benefit of a certain district around Pittsburg, and the stock market depending upon those interests, in doing a profitable business in this country and abroad."

5.—Collateral Phases of the Tariff Question.

Militant Aspects.—In considering the tariff of the United States

* Address on "The Tariffs of the United States," Leeds, Nov. 13, 1890.

from the point of view of its influence on British industry, we cannot ignore the possible example that it has set to other nations, and which in the future it may conceivably offer to our own. We need not discuss this point at any length. It would be unsatisfactory to attempt to discuss it from a purely controversial standpoint. But it is at least permissible to point out that not a few leading manufacturers have expressed dissatisfaction with a condition of things that enables other countries to enter British markets without let or hindrance, while excluding us from their own, and under which Britain is steadily increasing her imports of foreign manufactured goods, while leading statesmen have pointed out that this country, having by its economic policy given a practical sanction to this system of unrestricted imports, has no equivalent to offer in commercial negotiations with other nations.*

The British Point of View.—From the British point of view, the main interest in, and the chief effect of, the United States tariff take two forms—that of excluding our products from the markets of that country, and that of underselling us in our own. As regards the former, the fact is so well known that I need not pile up figures to prove it. Suffice it to say that our total iron and steel exports to the United States are now only about one-fifth of what they were ten years ago, although, even now, the tariff does not entirely shut out European iron and steel, seeing that pig-iron and billets are being imported from Europe while I write. As regards the latter, I should recommend those who are interested in following the subject further to read the evidence given in May last before the Industrial Commission now sitting in the United States, and especially that tendered by my old friend, Mr. Edward Atkinson, of Boston, the "Adam Smith of the United States"; by Mr. Byron N. Holt, secretary of the Tariff Reform Committee of the American Reform Club; and by Mr. H. W. Lamb, president of the New England Free Trade League, on the extent to which American manufacturers have had to quote lower prices than those quoted to home consumers, in order to secure foreign trade, and on the influence of the tariff generally. Mr. Holt declared, as regards tinplates, that "as the trust, for at least a part of the year, was supplying plates for export at about a dollar a box below the quoted prices, it certainly did not need more than a duty of half a cent per lb. to protect it from foreign competition." And again, "late in 1889, when wire nails were being sold at from 3·10 dols. to 3·53 dols. per keg to Americans, large quantities were being exported at from 2·14 dols. to 2·20 dols."; and finally, "when barbed wire was being sold to Americans at 3·67 dols. to 4·13 dols. per 100 lbs., it was being sold to Canadians for 3·25 dols., and to more remote foreigners at 2·20 dols. per 100 lbs." From this it would appear that between the highest price for wire nails quoted to Americans and the lowest contemporaneous price quoted to foreigners there was a difference of about 60 per cent., and in the similar case of barbed wire there was a difference of about 90 per cent. against the home consumer. These differences were made possible by the tariff.

* Lord Salisbury himself, in his speech at the Mansion House, in 1890, hinted that England might possibly be forced into a policy of retaliation against other countries.

But the testimony did not end here. It was further stated before the same Commission that "perhaps at no time (in 1899) was the export price within 50 per cent. per 100 lbs. of the American price"; that "the average difference probably considerably exceeded half a cent per lb. the minimum duty on wire nails"; that "it is probable that the average price of rails exported was considerably more than 5 dols. per ton below the home market price—our steel rail tariff bill is therefore about 10,000,000 dols. a year"; that "plain wire is quoted to the Canadian dealer 11 dols. per ton lower than to the home dealer. It is," adds this witness, "reasonable to suppose that one-half of the 108,000,000 dols. profit made by the constituted companies of the Steel Corporation in 1900 were tariff profits, absolutely unnecessary to protect any of these industries. In fact, it is certain that, if prices had been lower, consumption would have been greater."

I may here point out that while Great Britain, according to the official records of the United States, took from that country an average of more than 500,000,000 dollars' worth of merchandise during the last four years, the average imports of British produce into the United States have not exceeded one-third of that figure, while of that one-third from one-half to two-thirds are subject to more or less prohibitory duties. This is not a trade relationship which the people of this country can regard with perfect equanimity. Americans can hardly be surprised if in Great Britain there is an increasingly strong impression that in matters of commerce our American friends, like the Dutch described by Hudibras, have a habit of "giving too little, and asking too much."

Effect of the Tariff on Prices.

The Americans generally dispute the argument that a tariff for protection tends to keep up prices to the home consumer, and in support of their attitude on this subject they point to the fact that the prices of coal, iron, steel, and other commodities are, and have been, materially lower in the United States than in Great Britain. This view opens up questions of vast range, which it would take much space to handle. The other side of the argument obviously is that prices of commodities in the United States have declined, not because, but in spite of, the tariff, and it needs no argument to prove that if there had been no tariff in the year 1901, when American prices of iron and steel were generally 20s. to 40s. per ton higher than in Europe, the imports into that country from Germany and Great Britain would clearly have tended to reduce prices to American consumers. Even now, therefore, the tariff continues to influence home prices in the United States.

At the same time, it is by no means clear that a high tariff does necessarily involve a high range of prices in the protected country, and in the United States within the last few years prices have touched a very low level, in spite of the tariff. Take, as a case in point, the statistics of steel rails. When the steel rail industry was begun in the United States in 1867, the rate of duty on imports was 45 per cent. *ad val.* This rate was continued until

1871, when it was made a specific duty of 28 dols. per ton, which was reduced to 17 dols. per ton in 1883, to 13 dols. 44 cents in 1890, and to 7 dols. 84 cents in 1894, at which figure it has since been maintained. In spite of these duties, however, the average price of steel rails in the United States fell from 28 dols. in 1897 to 17 dols. 62 cents in 1898, and in the latter year the average American price was probably under the average of any other country.

Effect of the Tariff on Individual Concerns.

Many hold that the tariff has mainly been responsible for the great fortunes made by the typical millionaire, and the case of Mr. Andrew Carnegie is often quoted as a conclusive proof of this theory. I should not have dealt with an individual example in this connection, but for the fact that it stands out so prominently in the recent history of the American iron trade as to make it almost impossible to ignore it in the consideration of this phase of the question. Moreover, I have had the privilege, on more than one occasion, of comparing notes with Mr. Carnegie, and of knowing something more of the facts than "the man in the street"; and while I would not, of course, make use of any of the facts and figures brought to my knowledge in this way, I am quite at liberty to deal with facts that are common property in the light of the aspects thus presented.

Everyone who makes any pretensions to a knowledge of the recent history of the American iron and steel industries must be fully aware that during one of the most critical periods in its career the operations of manufacturing firms, and not the least so those engaged in the steel rail industry, were not uniformly successful. In the years 1896-98, the principal firms concerned in the American rail industry were the Carnegie Steel Company and the Illinois Steel Company, afterwards merged in the Federal Steel Company. But it is a well-known fact that over a large part of this period the Illinois Company failed to make profits, while the Carnegie Steel Company did remarkably well. The difference of results is mainly, if not wholly, due to differences in location, resources, and administration; and it is hardly likely to be claimed that the tariff was the cause of those differences, since its influence equally affected both. No doubt in the earlier history of the rail trade, profits were large, but on a relatively small product, for in 1875, when the Carnegie Company started, the total American production of steel rails was only 259,000 tons.

Trusts and the Tariff.

In America the question has many times been raised of late whether there is not a large degree of inter-dependence between industrial combinations and tariff duties. On this subject the United States Industrial Commission recently reported:—

"Protective tariffs do not seem to have been of special significance in the formation of industrial combinations in Europe, although in many cases the combination has been enabled to take advantage of the protective tariff in the way of securing higher prices. In free-trade England the combination movement seems to have developed considerably further than in protectionist France; but,

on the other hand, the movement towards combination has gone much further in extent in Austria and Germany, both protectionist countries, than in England, although in England the form of combination is generally more complete. Dr. Liefmann, in an article on combinations in England, expresses the opinion that the chief reason for the lesser development of monopolistic combinations in England and the continuance of severe competition in branches of industry in which in Germany there have existed for a long time very rigid combinations—for example, the coal industry—ascribes the cause rather to the principle of extreme individualism in England, which has a much firmer hold on business men, in his judgment, than in Germany; and this appears, on the whole, to be the right conception.

"On the other hand, there can be no doubt that the combinations at times make use of the tariff. In France, Germany, and Austria the tariffs seem in general to have been levied with the idea of furnishing a sufficient protection against foreign competition without placing them much higher than was necessary to cover the normal difference in cost of production. The Governments seem inclined to stand firmly by their protective policy, and there seems to be no very active propaganda hostile to it."

Rebates and Drawbacks.

In a number of Continental countries, tariff laws are got behind by rebates and drawbacks, which, however, are probably less common in the United States than in some European countries, and which, speaking generally, the Americans do not seem to love, as applied to their own country. Mr. John H. Converse informed the Industrial Commission in 1901 that in cultivating the foreign market for locomotives some very high tariffs are encountered by the Baldwin Company. In Russia, for example, the duty on a locomotive is 4 cents a pound, and is fully effective of its purpose to protect Russian manufacturers. In dealing with the Russian Government, however, his company, who in four or five years had supplied about 150 locomotives for the Trans-Siberian Railroad, did not encounter the tariff, as their contracts provided for delivery on board steamer at a Russian port. In the majority of foreign countries the railway system is largely Governmental, and the tariff question is thus eliminated from the transaction. At the present time, he said, it was not necessary to import material for locomotives constructed for American railways, but locomotives for export contracts sometimes called for certain appliances or parts of foreign manufacture. Such parts are imported, and the duty paid thereon is rebated in the form of drawback when the finished locomotive is exported.

The provisions made under the United States tariff for rebates and drawbacks are not remarkable so far as iron and steel are concerned. In the case of tinplates drawbacks are allowed on re-exports for certain purposes, but the elaborate French system of *aquits à caution* has no counterpart on the other side of the Atlantic.

CHAPTER XXII.

Associations of Employers in the United States.

The American Iron and Steel Association.

FOREMOST among the employers' associations of the United States stands the American Iron and Steel Association, with its headquarters in Philadelphia, and Mr. James M. Swank as its secretary and general manager. The association has been carried on for well on to half a century, and during more than half of that period it has been a most influential expression of the will of the people of the United States with regard to questions of tariff. It has also, with rare efficiency, collected and circulated the statistics of the production and distribution of iron and steel in that country, in the form of a valuable annual report, which corresponds in some respects with the annual statistical reports of the British Iron Trade Association, and it does a variety of other useful work.

In the original constitution adopted the first article was as under:—

"The general objects of this association shall be to procure regularly the statistics of the trade both at home and abroad; to provide for the mutual interchange of information and experience, both scientific and practical; to collect and preserve all works relating to iron and steel, . . . and, generally, to take all proper measures for advancing the interests of the trade in all its branches."

The original association was reorganised in 1864 and its name enlarged to the American Iron and Steel Association. A constitution was adopted, the first article of which was a verbatim copy of that of the American Iron Association above quoted.

From 1864 to 1900, a period of thirty-five years, the association has had only four presidents, and during the same period the Hon. Abram S. Hewitt has continuously served as one of its vice-presidents. Another vice-president, Mr. Wharton, has served since 1875. Still another vice-president, William Metcalf, has served since 1884. In the same period of thirty-five years the association has had only four secretaries, its present secretary, who has also been general manager since 1885, having entered upon his duties in 1873.

National Metal Trades Association.

The increasing aggressiveness of trade unions, and the difficulties that had been found in a number of cases in dealing singly with labour, led last year to an organisation of iron, steel and machinery manufacturers, which is one of the most important and influential hitherto established in the United States.

At a meeting of manufacturers of machinery and others concerned in the metal trades of the United States, in June of 1901, the following declaration of the basis on which machine shop proprietors will operate their plants was adopted:—

"We, the members of the National Metal Trades Association,

declare the following to be our principles, which shall govern us in our relations with our employés:—

"Since we, as employers, are responsible for the work turned out by our workmen, we must therefore have full discretion to designate the men we consider competent to perform the work and to determine the conditions under which that work shall be prosecuted. The question of competency of the men being determined solely by us, and while disavowing any intention to interfere with the proper functions of labour organisations, we will not admit of any interference with the management of our business.

"Disapproving absolutely of strikes and lock-outs, the members of this association will not arbitrate any question with men on strike. Neither will this association countenance a lock-out on any arbitrable question unless arbitration has failed.

"Employment.—No discrimination will be made against any member of any society or organisation. Every workman who elects to work in a shop will be required to work peaceably and harmoniously with all his fellow employés.

"Apprentices, helpers and handy men.—The number of apprentices, helpers and handy men to be employed will be determined solely by the employer.

"Methods and wages.—We will not permit employés to place any restriction on the management, methods or production of our shops, and will require a fair day's work for a fair day's pay.

"Employés will be paid by the hourly rate, by premium system, piece work or contract, as the employer may elect.

"It is the privilege of the employé to leave our employ whenever he sees fit, and it is the privilege of the employer to discharge any workman when he sees fit.

"The above principles being absolutely essential to the successful conduct of our business, they are not subject to arbitration.

"In case of disagreement concerning matters not covered by the foregoing declaration, we advise our members to meet their employés either individually or collectively, and endeavour to adjust the difficulty on a fair and equitable basis. In case of inability to reach a satisfactory adjustment, we advise that they submit the question to arbitration by a board composed of six persons, three to be chosen by the employé or employés. In order to receive the benefits of arbitration the employé or employés must continue in the service or under the orders of the employer, pending a decision. In case any member refuses to comply with this recommendation he shall be denied the support of this association unless it shall approve the action of said member.

"Hours and wages.—Hours and wages being governed by local conditions shall be arranged by the local associations in each district. In the operation of piece work, premium plans or contracts now in force or to be extended or established in the future, this association will not countenance any conditions of wage which are not just, or which will not allow a workman of average efficiency to earn at least a fair wage."

After the statement that the matter of wages is purely a local

and not a national issue the position of the association is defined as follows: "We declare that the Machinists' Union has, through its national and local officers, broken faith with us and proved to be an irresponsible body, with whom we can make no contracts that will be binding upon them.

"We recognise the right of any man to belong or not to any religious, political or economic sect, as he may see fit, also his right to leave our employment at his free will, and his right to sell his labour at the best price he can command. We maintain our inalienable rights to employ a man whether he belongs or not to any organisation and at wages mutually satisfactory, and also to discharge him at our discretion. We insist that the management of a shop is in the hands of the employer and is not to be interfered with by the employé.

"We insist that a fair day's work shall be given for a fair day's wage, and we will give a fair day's wage for a fair day's work.

"We believe that a shortening of the working hours or an increase of wages can only be brought about by the hearty co-operation of employer and employé in advancing and not in retarding production and by introducing and not fighting improved methods.

"We decry strikes and lock-outs as unbusinesslike and unnecessary and believe that all disagreements can be adjusted by other means, and the condition of employer and employé both benefited more by harmonious progress than by strife and discord."

The attitude assumed by American employers in cases of dispute with workmen may be gathered from the following resolutions adopted at the conference between the National Metal Trades Association and the International Association of Machinists in 1900:—

"*Whereas:* In the joint agreement adopted by the administrative council of the National Metal Trades Association and the International Association of Machinists, it was agreed that all pending disputes and disputes hereafter to arise between members of the respective organisations—that is, between an employer and his employé or employés—should be settled by arbitration; and

"*Whereas:* It was further agreed that, pending such arbitration, no strike or lock-out should occur.

"*Be it resolved:* That for the purpose of providing means by which the employer or employé may derive the benefits of this agreement, the following methods shall be pursued:

"When a dispute shall arise between an employer and his employé or employés, every reasonable effort shall be made by the said parties to effect a satisfactory adjustment of the difficulty; and in case such difficulty cannot be settled between the employer and his employé or employés, it shall be referred, on the part of the member of the National Metal Trades Association, to the chairman of the district in which he is located; and by the employé or employés to such representative as he or they may select, who shall by all means in his or their power endeavour to adjust the difficulty to the satisfaction of both parties.

"Should this committee fail to make such adjustment, then either

party shall have the right to ask for a conference between the presidents of the two associations or their representatives. In the event of their being unable to adjust the differences satisfactorily, then it shall be referred to arbitration, as provided in the agreement of May 18th, 1900. The findings of this arbitration, by a majority vote, shall be considered as final as regards the case at issue.

"Pending adjudication by arbitration, there shall be no cessation of work at the instance of either party to the dispute."

The clauses in the rules of the Metal Trades Association with regard to disputes are founded on experience, and are probably worth the attention of British manufacturers. The first act is to request the workmen concerned to attend before the District Committee in order that the matter at issue may be investigated. If the workmen refuse to appear, the committee is to dispose of the case by a majority in the usual way. The parties directly concerned are not allowed to act on the committee. If the committee do not succeed in bringing about a settlement, they may proceed to defend the member concerned by procuring men to work for him, by affording compensation for loss of output, or by themselves undertaking to manufacture for him. Members are warned against taking any action that would be likely to lead to a strike without consultation with the council of the association, and no member is authorised to settle a question involving a question of general interest without previous submission to the council.

One of the articles provides that if the committee determine to protect the member concerned by supplying him with men, the "other members of the association shall be required to supply such member, and to keep him supplied until the District Committee shall declare the trouble ended, with competent workmen to the extent of 70 per cent. of the maximum number he employed according to his last report. The proportion to be supplied by each member shall be determined by the president and secretary upon the ratio that the number employed by him bears to the total number employed by the whole membership of the association. If, after five days, it shall appear to any member that it will not be possible for him to supply his quota of men, he shall immediately notify the administrative council, who will, in case of such failure, compensate the aggrieved member as provided for by Section 2. Should the number of men required be less than one man for each of the members of this association, or if it be impossible to otherwise formulate an equitable requirement, the president and secretary shall group together in a fair and reasonable manner certain members, and require them to supply the man or men, in default of which they shall severally pay their proportionate assessments for man or men not furnished.

"If the other members of the association shall not supply the member whose men have struck with competent workmen to the extent of 70 per cent. of the maximum number he employed, according to his last report, the association shall compensate such member, and the administrative council shall determine the amount of the compensation which shall be paid to the member out of the reserve fund of the association. Such compensation shall in no case exceed the sum of two dollars ($2·00) per man per day for every man not furnished him

after the expiration of seven days from the date of the committee's decision. Such compensation shall terminate or be varied at the discretion of the administrative council."

The National Founders' Association.

This, like the Metal Trades Association, is an organisation chiefly called into existence for the purpose of taking collective action in reference to all matters of mutual interest affecting the relations of capital and labour. It is, like its prototype, founded on principles that are designed to secure cordial and friendly relations, and to prevent as far as possible the occurrence of disputes between employers and employed. The membership is large and extends over the whole of the United States, although chiefly concentrated in the States of Pennsylvania, Ohio, and Illinois. One of the matters brought before the association in 1901 was a demand by the iron moulders that the foundries of Philadelphia should be operated under the rules and regulations of the Iron Moulders' Union—a demand which, after some negotiation, was withdrawn. In the same year the wages of skilled moulders in Philadelphia were fixed at 27½ cents (2s. 1½d.) per hour, or 16 dols. 50 cents (68s. 8d.) per week of 60 hours. Other clauses of the same agreement provided that inferior workmen should be paid less wages as agreed upon, but at the same rate; that double time be paid for Fourth of July and Labour Day, Thanksgiving Day, and Christmas, that "arbitrary limitations of output" should be "viewed with disfavour" and opposed; and as regards piece work the following important resolution was adopted :—

"It is agreed that nothing in the foregoing shall be construed as prohibiting piece or premium work, and when it is desired on the part of the foundryman that his work shall be done under the piece work or premium system, it is agreed that the wages of the moulder shall be based so that he may earn a wage not less than if working by the day. This is understood as applying to moulders who are competent to do an equal amount of work and of equal quality to the average moulder in the foundry in which he is employed.

"Where the foundryman and moulder cannot agree on the piece price for a certain piece of work, the foundryman is to have the work done by the day for a period of a day or more, according to the nature of the work, in order to establish a fair and equitable wage-rate on the work in question.

"It is further agreed that nothing in this agreement shall be construed as preventing a moulder from agreeing with his employer on a piece price as soon as he is given a pattern."

Another almost equally important contract is made in the following paragraph, and one which British employers would sometimes find it to their interest to insist upon :—

"There being in some foundries a grade of work calling for less skill than is required by the ordinary moulder, this grade of work being limited in quantity, it is agreed that nothing in this agreement shall be construed as prohibiting the foundryman from employing a moulder to make such work and paying for same at a rate that may be mutually agreed upon between the moulder and the foundryman. It is understood that a moulder who is working for and receiving a rate of wages of twenty-seven and one-half (27½) cents per hour or over, is not to be asked or expected to make the grade of work referred to above for any less wage-rate than he is regularly entitled to under this agreement. This does not give the moulder the right to refuse to make the work if it is offered him at his regular wage-rate."

The National Founders' Association had in 1901 a membership of 400 firms, who claimed to represent a capital of 300 million dols., and to employ upwards of 30,000 moulders, while the Iron Moulders' Union of North America, with which it has mainly to transact its business, and which is its labour counterpart, had at the same time about 35,000 members, and a yearly income of 400,000 dols.

A recent writer on manufacturers' organisations in the United States* remarks that "they have broadened the members' views and made them tolerant of one another. Without cultivating the slightest tendency towards trusts, ... these associations have led to serious inquiries into shop practices, and to the almost total extinction of every undesirable condition. They have in a large degree brought about a uniformity of action along well-considered lines, and elevated the tone of the whole industry. The Labour Unions have shown manufacturers the necessity of combining for protection, and some, at least, of the Manufacturers' Associations have shown the way to peace without employing drastic measures, and without dishonour to either side."

* H. W. Hoyt, on "Manufacturers Associations, Labour Organisations, and Arbitration," in the *Engineering Magazine* for May, 1900.

CHAPTER XXIII.

The Profits of American Iron and Steel Works.

General Considerations.

THE amount of profit which can be made in any particular branch of industry, and by any particular person or firm engaged in that branch of industry, depends on a variety of conditions and considerations that are never in any two cases quite the same. There is, moreover, such a wide disparity between those conditions that it is practically impossible to adopt any figure that will fairly represent an average of them at any particular period. This latter qualification is one of the utmost importance, because in most countries, and in the United States more than in most others, the conditions of one period are very far from representing those of another. The appreciation of the value of raw materials, the reduction or increase of the costs of transport, the conditions and the costs of labour, the opening up of competitive supplies, and many other fluctuations are liable to create differences of cost which react upon prices and profits within a wide range.

It is now a considerable time since the Carnegie Steel Company announced as their future policy that there can only be one profit from the ore to the finished material. It is a curious comment on the uncertainty of American economics that the head of this great enterprise, only a few years before, had declared in effect that the best way of dealing with raw materials was to buy them in the open market, and that it was not his business to embark on the possession and working of either iron ore mines or collieries. Indeed, it was not until 1890 that Mr. Carnegie appears to have so far altered his views on this matter as to invite Mr. Frick, who controlled great coke properties in the Connellsville region, to become a partner in his steel business, which the two together worked up to such a point of magnitude and importance as to overshadow everything else of its kind in the world, and ultimately to prove the basis of the Steel Corporation.

The profits which a great capitalistic force like the United States Steel Corporation can make out of a particular branch of the industry in which it is engaged are not usually disclosed to the outside public. The only general fact made public is the amount of profit earned over the whole field of operations. Of course, the amount of profit earned in each branch—in the mining of coal and iron ore, in the manufacture of coke, and in the production of pig-iron and steel, etc.—are known to the directors, but they are not disclosed in detail. The practice is to have each branch and department so regulated that it has to pay its own way, and hence no one department is permitted to lean on any other.

There does not appear to have yet been discovered in the United States, more than our own country, any rule, law, or process where-

by profits can be steadied and preserved free from fluctuation. This can only be done with partial success when prices of commodities can be kept at a more or less uniform level, if at all. Even then there cannot be uniformity of profits unless there is uniformity in all the conditions of production—in the costs of raw materials, in labour, in efficiency of administration, in first cost of plant, and in a hundred other things that more or less influence the final result.

Profit Fluctuations in the American Iron Trade.

An interesting statement of price and profit fluctuations was published some time ago by the United States Industrial Commission, showing that in the year 1901 the profits per ton in making American Bessemer pig-iron varied between 9s. 3d. and 23s. 9d. per ton; that the profit on steel billets fluctuated between 6d. and 7s. 6d.; and that the profits on rails varied between 2s. and 18s. per ton. In this connection the following table presented to the Commission is of interest, as showing average costs, prices, and profits for Bessemer pig at Pittsburg from 1890 to 1900:—

Year.	Average Cost of Production. s. d.	Selling Price. s. d. s. d.	Margin. s. d. s. d.
1890 ..	62 0	66 6 to 94 6	4 6 to 32 6
1891 ..	51 0	60 6 „ 66 0	9 6 „ 15 0
1892 ..	53 0	55 6 „ 62 6	2 6 „ 9 6
1893 ..	45 6	44 9 „ 55 6	— „ 10 0
1894 ..	34 6	41 3 „ 52 6	6 9 „ 18 0
1895 ..	38 0	40 0 „ 68 6	2 0 „ 30 6
1896 ..	48 0	44 0 „ 53 6	4 0 „ 5 6
1897 ..	38 0	37 9 „ 43 0	— „ 5 0
1898 ..	39 0	40 0 „ 42 6	1 0 „ 3 6
1899 ..	41 0	44 0 „ 100 0	3 0 „ 59 0
1900 ..	61 6	53 6 „ 100 0	— „ 38 6

One of the most disturbing influences affecting prices and profits in the United States has been the fluctuations in the cost of iron ores. The Industrial Commission published, in November of 1901, an interesting table, showing the prices at which Lake Angeline ores were sold at lower Lake Erie ports during the twelve years ended 1901. The lowest price over that period was 10s., in 1894, and the highest was 24s., in 1890. This is a difference in range of 14s., or 140 per cent. It is probable that the difference was almost entirely profit to the mine-owner, inasmuch as the elements of the cost of production would not greatly vary in the two periods, although transport in 1894 would be a little lower.

In the year 1900 about 20 million tons, or about 72 per cent. of the whole of the iron ore produced in the United States, were raised in the Lake Superior region, and of that quantity about 41 per cent. was raised in the cheap mines of the Mesaba range, so that about 30 per cent. of the total iron ore output of the country was Mesaba ore. There is a good deal of importance attached to the question how far the use of Mesaba ore can be carried in blast furnace practice. These ores are practically dust, and generally only 40 per cent. is used in furnace mixture, because of the risk otherwise incurred of "hangs" and explosions. It does not appear to be anticipated that this proportion of

Mesaba ore in a furnace charge can be much exceeded, and if this be so the limit of their use would appear thereby to be fixed. Of course, the concern that can utilise a larger percentage of this cheaper ore is likely to make greater profit than a rival that has to limit its use.

The differences that are liable to distinguish, and do actually distinguish, the concerns that have their own supplies of minerals from those that have not, are illustrated in the latest report issued by the Pennsylvania Steel Company. This concern was recently being reorganised, with a considerable increase of capital, when it was stated that if the new capital called for had been available, and invested in properties supplying coke and ore, the total savings that would have resulted over the prices the company had to pay in the open market would have been 2,907,800 dols. in 1900, and 1,376,000 dols. in the following year, although it was admitted that these were not figures of a normal or average character.

Net Earnings and their Disposal.

Many examples of remarkable profits, as well as notable fluctuations of profit, might be quoted as illustrative of the unstable conditions under which the iron trade of the United States has hitherto been carried on. Let one case suffice. A document placed in my hands purports to show the annual dividends paid during a period limited to twenty-nine years by the Jefferson Furnace Company, which, so far as I know, is no wise exceptional in its circumstances. Over this period there were paid two dividends of 200 per cent. each, eleven others of over 100 per cent., four others between 50 and 100 per cent., and during five years the dividends were *nil*. The dividends paid over the whole period amounted to 1,917 per cent. on the capital, being an average of 66 per cent. per annum!

A general idea of the financial basis of the leading works of the United States may be gathered from the form and the details of a typical balance-sheet, such as that of the Republic Iron and Steel Company, which, for the year ended June 30th, 1901, showed a total of 51,000,000 dols. in assets, of which the chief items are :—

	Dols.
Real estate, plants, and machinery	41,093,724
Raw and finished materials	3,328,850
New construction...	2,382,378
Accounts and bills receivable	2,527,209

The rest was made up of stocks in other companies, new gas pipe lines, cash on hand, etc.

On the side of liabilities figure the following items :—

	Dols.
Preferred stock	20,306,900
Common stock	27,191,000
Current accounts payable	1,685,350

and dividends, reserves, and surplus. The fluctuations to which concerns of this kind are liable are notably indicated by the fact that the net earnings of the Republic Company fell from 5,684,101 dols. in 1900 to 1,034,248 dols. in 1901, and the net profits from 3,643,729 dols. in 1900 to 309,099 dols. in 1901. This means that in 1901, which was generally

regarded as a good year, the Republic Iron and Steel Company only earned about one-twelfth of the net profits earned in the previous year, or a little over one-fifth of the amount needed to pay the 7 per cent. dividends on its preferred stock, leaving nothing at all for common stock. Similarly, this liability to large fluctuations makes it difficult to keep up the necessary efficiency of plants. The Republic Company spent in 1900 36 per cent. of their net earnings in improvements, etc., which was remarkable enough, but in the following year they spent 70 per cent. of their net earnings, and more than twice the amount of their net profits, under the same head.

Concealment of True Profits.

It is not always an easy matter to arrive at the financial results attending the manufacturing or mining operations of large firms or companies. When the profits are exceptionally great, there are often good reasons for taking as much care as possible to conceal them. Questions of taxation, rating, labour remuneration, transportation charges, and other similar matters are liable to be adversely affected by a disclosure of excessive profits, and in the United States no argument has so frequently been used against the maintenance of the tariff on iron and steel as the exceptional profits earned by the Carnegie Company, although I am not aware that until recently these profits have ever been disclosed.*

A few years ago, Mr. Abram S. Hewitt exposed in Congress some of the methods adopted by the manufacturing concerns of the United States in order to avoid the payment of taxes on the dividends earned, an *exposé* which throws a good deal of light on the great difficulty of ascertaining the real profits of such properties. He showed that after paying 22 per cent. dividend in 1881, one company with a total capital of 2,000,000 dols. had 3,286,423 dols. on hand as undivided profits, which must have been earned in the two previous years. A tax is paid in the State of Pennsylvania on dividends, and the Pennsylvania Company, not caring to pay tax on a dividend of more than 22 per cent., devised an ingenious plan to distribute this surplus in another form. They bought from the Pennsylvania Railway Company 5,000 shares of the 20,000 which formed their capital, at 265 dols. a share, although the stock was worth much more, and they sold this stock to their shareholders for 100 dols. a share. In this way they divided 825,000 dols. of surplus profits without calling it a dividend, so that the Company made a free gift to the shareholders of 165 dols. per share. This arrangement was disclosed owing to the Courts being called on to decide whether this stock, in the estate of John Edgar Thomson, who held 1,000 of the shares, should, on his death, be added to the principal as a stock division, or be regarded as income. The Court treated the 825,000 dols. as a dividend.

Artificial Influences.

On the American continent profits of manufacture are liable to be artificially influenced by two conditions that do not exist, and of which

* As the result of some threatened litigation between Mr. Carnegie and Mr. Frick, the profits of that enterprise in 1900 were computed at over 20 millions of dollars.

there are no equivalents, in a free-trade country like our own. One of these is the tariff; another is the bounty system. We have already spoken of the American tariff, and shown how it influences selling prices—and, consequently, profits more or less—both at home and abroad. The other system is now in full operation in the Dominion of Canada, and must play a most important part in the financial results arrived at there for some years to come.

The Dominion Iron and Steel Company have issued a statement that if their estimate of an annual production of 400,000 tons of iron and steel per annum be realised, they will have to receive from the Canadian Government up to the end of 1907, bounties to the total amount of 8,095,000 dols. (£1,621,000), or an average of £231,572 per annum, which will reach its maximum with £415,000 in 1902, and will fall to a minimum of £45,000 in 1907.

Despite, however, the existence and the influence of tariffs and bounties, the values of iron and steel properties in countries like the United States and Canada are as liable to be affected by depression as those of our own country. In a preceding chapter we have shown how liable American industry has been to panics and crises in the past. The experience of nearly every iron-making enterprise in the United States, up to quite a recent date, sufficiently proves that that liability continues. The case of the greatest iron-making enterprise in the southern States may be quoted in proof of this fact. That important concern a few years ago was in a state of depression almost unknown in this country. The market value of its shares had fallen to 17 dols. In less than a year there was a rise in the market value of its shares from 17 dols. to 126 dols., which is an experience that has probably never fallen to the lot of any iron-making concern before. This was due to a rise in the value of its pig-iron from 7 dols. to 18 dols. per ton; but these figures do not indicate the profit made. A comparatively small portion of the output of pig-iron usually realises the current market price for the producers, as large deliveries are made on account of contracts entered into many months before at prices far below current figures. For example, at the time that pig-iron was worth from 15 dols. to 18 dols. per ton at furnace, the deliveries of the Tennessee Coal, Iron and Railroad Company are said to have averaged in one such month only about 9·50 dols. per ton, and yet the company is credited with having made a net profit of nearly 250,000 dols. on that month's business. Often before current prices can be realised the boom has disappeared.

The Census figures throw some light on the important subject of the average profits earned in the iron and steel industries of the United States. Taking the total expenditure as above recorded at 716,376,000 dols. for 1900, the value of the products of the American iron and steel industries as a whole for the same year is recorded at 835,759,000 dols., leaving a balance of 119,383,000 dols., which is about 20½ per cent. on the returned capital of 573,000,000 dols.

On collating the figures for 1890 in the same way, it appears that the difference between the cost of production and the value of the products only allowed sufficient to pay 9 per cent. on the returned capital invested, although 1890 was a year of good trade.

CHAPTER XXIV.

The Capacity of American Iron and Steel Works.

JUST as I am about to close this Report, Mr. Swank sends me a copy of his admirable *Directory of the Iron and Steel Works of the United States*, which supplies some missing links in the chain of evidence submitted in the preceding chapters as to American conditions and progress. I was quite prepared to find that during the last two or three years the quantitative advances made by the United States alike in the pig-iron and in the steel industry had been exceptional. Of this fact, during my recent visit, I saw evidence on every hand. But I was not prepared to find that the sum total of these advances had been nearly so great as they are proved by Mr. Swank's figures to have been.

Blast Furnaces and Steel Works.

The Directory shows that the total capacity of the blast furnaces in 1901 was 24,812,037 tons, which is an increase of nearly five million tons a year on the capacity recorded for 1898. There were, at the end of 1901, 12 blast furnaces being built, and as these are of the newest type, their average annual output may be taken at about 150,000 tons, which would further increase the capacity since 1898 by nearly two million tons a year.

The capacity of the steel works of the United States in the same year is officially given at the following figures :—

	1898. Gross tons.	1901. Gross tons.
Bessemer steel	10,552,000	12,938,000
Open-hearth steel	3,522,250	8,289,750
Crucible steel	177,000	175,000
Totals	14,251,250	21,402,750

Here we find that the total increase of capacity within about two and a half years has been not less than 7,151,700 tons, including that of 50 furnaces being built or rebuilt for the open-hearth process. There are now 35 Bessemer steel works and 112 open-hearth steel works built in the United States, with 12 others being erected.

So far as our enquiries went, we found that the great majority of the new plants were being erected to smelt Lake Superior ores and Connellsville coke, in cases where the purpose is to make pig-iron, and to use either Bessemer (hematite) or basic pig-iron, where the proposal is to make steel. The extensions outside of the Pittsburg district are considerable, but by no means comparable within what may be regarded as the sphere of influence of that centre. When I speak of

the Pittsburg sphere of influence, I mean to include the works of Youngstown, only 65 miles distant, and those of Cleveland (Ohio), which are nearly twice that distance, because they depend on the same sources of supply of raw material, and are subject to much the same costs of assembling those materials. I would go further, and add that this sphere of influence may be regarded as including "the Valleys," which is a generic name given to a group of industrial centres within a radius of three or four hundred miles of Pittsburg, although to some extent fed from other sources of supply.*

Recent Increase of Plants.

I have tried to put into reliable and intelligible form a statement of the various projects designed to increase the productive resources of the United States in iron and steel of all kinds, and had proceeded some considerable length in that direction when I found it so difficult to make the list complete, and therefore so liable to mislead, that I abandoned the idea of seeking to compute even approximately the extent of the increased resources of output now being provided or recently called into existence. From one end of the United States to the other it may be said that capital is seeking for, and has found or is finding, new outlets for investment in iron and steel plants and their collateral industries. A few of the more important developments in this direction are indicated in the following very partial list, with the approximate capital outlay :—

	Dols.
Pennsylvania Steel Company (increase)...	43,500,000
Cambria Steel Company (increase)	34,000,000
Colorado Fuel and Iron Company (increase) bonds ...	15,000,000
Tennessee Coal and Iron Company (increase) bonds ...	15,000,000
Sharon Coke Company	4,000,000
Empire Bridge Company	3,000,000
National Bridge Company	1,500,000
Sharon Steel Company (increase)	1,000,000
Pittsburg Steel Company...	3,000,000
Pittsburg Wire and Steel Company	2,000,000
Youngstown Iron, Steel, and Tube Company (increase)	3,400,000
Central Iron and Steel Company (increase)	4,000,000
Washburn Wire Company (increase)	2,250,000
Page Woven Wire Fence Company (increase) ...	5,000,000
Ashland Iron and Steel Company	1,000,000
Independent Steel Company	1,500,000
Colonial Steel Company	1,000,000
National Steel Refining Company	1,000,000
Chicago Tinplate and Can Company	2,500,000
Kokomo Steel and Wire Company	1,500,000
Sharon Tinplate Company (increase)	500,000
Total	145,650,000

* The Valleys include the following resources of pig-iron output :—

Valley.	Total blast furnaces.	Total make of pig in 1900.
Lehigh Valley	29	545,000
Schuylkill	18	441,000
Juniata	11	126,000
Shenango	17	800,000
Mahoning	14	1,002,000
Hocking	3	50,000

The total capitalisation of the iron and steel industries of the United States, in 1901, is stated by the Census at the sum of 2,000,000,000 dols., of which amount the United States Steel Corporation is credited with 1,400,000,000 dols. But in the above list, in the space of one year. competitors have appeared with a combined capitalisation of one-tenth of that of the Steel Corporation.

The Steel Corporation itself is not, however, idle, nor apparently likely to be so. At the time of its formation, in the spring of 1901, the Carnegie Steel Company were providing for an expenditure of some 20 million dols. on new blast furnaces, open-hearth plants, rolling mills, etc. The transfer of the Carnegie properties to the Steel Corporation has naturally involved a certain amount of overhauling and revision of these plans, but the expenditure now being incurred and provided for in the near future remains very considerable all the same. And so, more or less, with the other constituent companies.

In no branch of the trade is more activity apparent than in that devoted to the manufacture of sheets, for which the United States appear to have a most devouring appetite. The American Iron and Steel Association do not publish separate statistics of the output of sheets and plates, but the output of both together in 1900 was returned at 1,794,528 tons, while in the previous year it had reached the still higher figure of 1,903,505 tons. These figures do not include rail plate, of which there was a considerable additional output. And yet, at the end of 1901, there were 31 independent companies erecting new works, or making extensions to existing works, for the manufacture of sheets, including the Sharon Sheet Steel Company, with a 12-mill plant. This leaves out of account the extensions being made to the sheet steel works of the Steel Corporation, which are considerable. At Vandergrift alone, I found an extension of nearly a dozen mills provided for, and the management there has in view the ultimate increase of the total number of mills in a single line to 50! Of course, a very large part of this increase of demand goes into roofing and kindred purposes, and the possibilities of increase in this direction appear to be almost unlimited.

It is not enough to be able to point to isolated examples of great efficiency and capacity; the true test of both is the general practice of the country. That general practice, in the majority of cases, is difficult to set in specific terms, because it is not usually easy to get a group of examples that will be sufficiently representative and typical. To a certain extent this difficulty is met in the case of the United States by the information as to the capacity of output collected for his Directory by my friend, Mr. Swank. The estimates of capacity purport to be given by the manufacturers themselves, and even if a slight allowance is made for the not unpardonable possibility of some making their estimates too liberal to conform strictly to everyday conditions of working, the results in the main are sufficiently remarkable to attract much notice, if not a little envy, on the part of European rivals.

The estimates of capacity made to the secretary of the American

Iron and Steel Association for the iron and steel plants of 1901 are as under:—

Description.	Total No. Units.		Estimated annual total capacity. Tons.		Average annual estimated capacity per unit. Tons.
Blast furnaces	406	...	24,812,037	...	61,113
Bituminous furnaces only ...	261	...	20,771,200	...	79,583
Blast furnaces in Pennsylvania	147	...	10,673,025	...	72,605
„ „ „ Alabama...	45	...	2,363,500	...	52,520
„ „ „ Ohio ...	59	...	4,674,700	...	79,198
„ „ „ Illinois ...	20	...	1,955,000	...	97,750
Standard Bessemer converters	81	...	12,938,000	...	159,728
Open-hearth furnaces ...	453	...	8,289,750	...	18,299
Steel melting pots	2,896	...	175,000	..	61

The records of the American iron industry show that the capacity of the plants has enormously increased within the last few years, as we have seen in earlier sections of this Report. As a convenient stage in recent progress we may take the end of the year 1895, at which time, according to information obtained in the same way for the same Directory, the average annual capacity of the 469 blast furnaces then available was only 40,000 tons, or, say, one-third less, while the average of the 99 Bessemer converters works out at 96,000 tons a year, instead of 159,728 tons, and the average of the 225 open-hearth furnaces then built works out at 10,000 tons a year, instead of 18,299 tons. The same evidences of progress appear in all branches of the iron and steel industries.

The statistical progress made in other directions in the same interval is illustrated by the following figures: –

Capacity of		Dec., 1895. Tons.		Dec., 1901. Tons.
Blast furnaces... ...	...	17,373,637	...	24,812,037
Bessemer converters...	...	9,472,350	...	12,938,000
Open-hearth furnaces	...	2,430,450	...	8,289,750
Rolling mills	...	14,763,920	...	23,220,350

During this period of six years, the capacity of American blast furnaces has increased by 7,438,400 tons; of Bessemer plants by 3,465,650 tons; and of open-hearth plants by 5,859,300 tons; the total increase of steel capacity (in ingots) by both processes being 9,324,950 tons!

It is desirable, but not a little difficult, to convey an idea of what this enormous increase of manufacturing resources really means, in relation to the past demands of the civilised world. The increase alone in the American output of pig-iron in these six years is more than the total make of pig-iron throughout the world in 1860, and it is greater than the total annual output of pig-iron in the United States in any one year up to 1889. It also exceeds the total output of pig-iron in Great Britain in any one year up to 1880.

The increase alone of steel output in the United States in these six years is considerably larger than the total output of steel of all kinds throughout the world in any one year previous to 1890, and is about half a million tons more than the total make of steel in Great

Britain in any two years prior to 1897. Moreover, it is nearly three times as much as the total steel output of the United States so recently as 1887, and more than nine times as much as the total output of any one year up to and including 1880.

Judging, therefore, from the past, it would seem almost impossible that this phenomenal rate of progress could be justified by the prospective demand, either of the United States themselves or of the rest of the world. That, however, is so conjectural a matter, that I do not feel called on to pursue it any farther.

Since, in 1901, the total production of pig-iron—the greatest hitherto recorded—in the United States was some 16 million tons, and as the existing capacity of the blast furnace plants is nearly 25 million tons, it would seem as if there was already a reserve capacity of nearly nine million tons. Lest it might be supposed that this conjunction of circumstances implies a possible glut, I should probably add that the actual production must mainly be controlled by the availability of adequate and suitable supplies of raw materials. Not only so, but the situation is controlled to a large extent by the number of plants that can make pig-iron at a profit under conditions of keen competition. These two factors are always likely to keep the actual output well within the limits of the estimated capacity. Similar factors, including availability of pig-iron supplies of suitable quality, control the output of both Bessemer and open-hearth steel.

The Pig-iron Output of Different Countries.

The relation of the increase of pig-iron output in the United States to that of other countries, since the year 1870, is graphically illustrated in the diagram herewith (Fig. 74). It will be noted that in 1870 Great Britain was a very long way ahead of the other iron-making nations, and Russia held the most inferior position. In 1890 the United States left Great Britain in a second place. The vast strides which the United States have made since that time is very striking. The British line has, on the whole, been a fluctuating one, although no British fluctuations have been more remarkable than those of the United States in 1894-95. Germany and France have made more steady progress, and since 1890 the advance of Russia has also been more distinct.

It is probably among "the things not generally known" that Germany has the greatest number of Bessemer converters of any country in the world, although not producing the largest quantity of Bessemer steel. At the end of 1901, the Fatherland had 126 converters in existence, of which 28 were attached to plants that produce acid steel and 98 to basic steel plants. This compares with 81 standard Bessemer converters in the United States and 78 available converters in Great Britain. But the output of Bessemer ingots in the United States in 1901, with these 81 converters, was 8,713,302 tons, or fully twice the output of Germany with 126 converters, and fully five times the output of Great Britain with 78 converters.

As regards open-hearth plants, Germany, at the same date, had 239 open-hearth furnaces, of which 23 were built to produce acid and

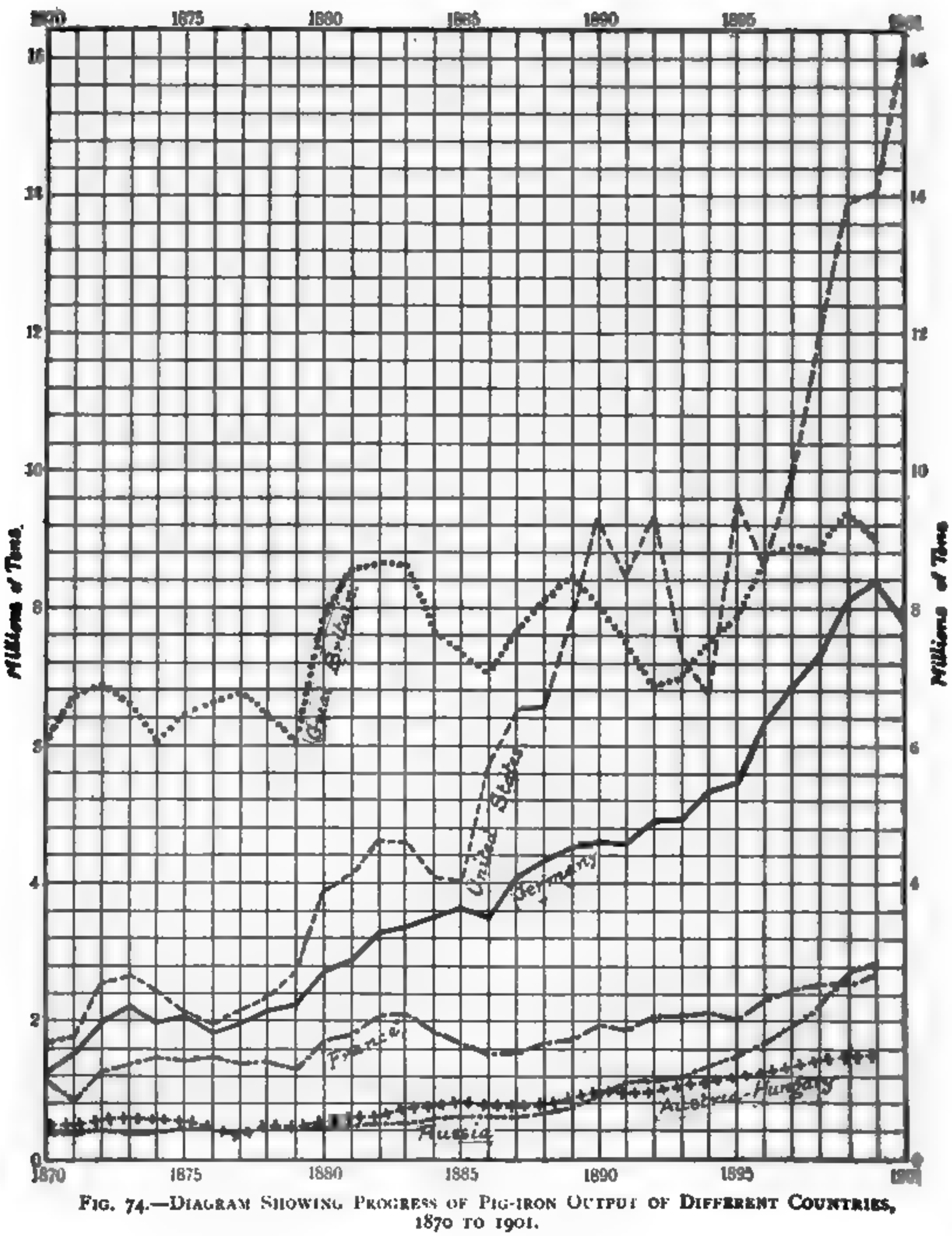


FIG. 74.—DIAGRAM SHOWING PROGRESS OF PIG-IRON OUTPUT OF DIFFERENT COUNTRIES, 1870 TO 1901.

216 to produce basic steel. This compares with about 500 open-hearth furnaces in the United Kingdom and 403 completed open-hearth furnaces in the United States. But the American plants produced in 1901 4,656,309 tons of ingots, and are stated in Mr. Swank's *Directory of the United States Iron and Steel Works* to have had a capacity—with 50 new furnaces being built—of not less than 8,289,750 tons per annum, while the British plants have never in any one year produced more than 3,250,000 tons, nor the German plants more than 2,200,000 tons.

The vast preponderance of the basic process in the plants of Germany are shown in these figures. It will be seen that 77 per cent. of the productive capacity of the Bessemer plants, and 90 per cent. of the capacity of the open-hearth plants, is designed for the basic process. In our own country the make of basic steel has never in any one year exceeded 850,000 tons, which may be taken as about one-sixth of the total output of steel of all kinds, and in the United States the actual output of basic steel in 1901 was 3,618,993 tons—all by the open-hearth process,—which is only 27 per cent. of the total output of steel by all processes. In both the United Kingdom and Germany considerable quantities of basic steel are made by the Bessemer process, whereas in the United States only the open-hearth is employed to produce that description of steel. This is a fact that may be said to be founded on conditions which in the older centres of the trade were unavoidable. The plants were there, and, whether the system was or was not the best, it had to be made use of. But in the United States, where the demand is so large as to afford facilities and opportunities for applying the system that is found to be the best, apart from established conditions, the use of the open-hearth alone in the basic steel industry indicates unmistakably that that system is preferred in practice, and is found to yield the best results. Not only so, but while the output of Bessemer steel ingots increased largely in 1901 over 1900, there has been no material increase in the plants available for the manufacture of Bessemer ingots. On the contrary, the total number of converters has fallen from 95 in April, 1898, to 81 in November, 1901. This decrease of 14 has lately been to some extent made up by the new plant of the Lackawanna Company in New York State, but this was the only new Bessemer plant in course of erection at the end of 1901, whereas twelve new plants were at that date being constructed to carry on the open-hearth steel industry, and thirteen other plants were projected. This means an enormous addition to the resources possessed by the United States for the manufacture of open-hearth steel. Indeed, the computed capacity of the American open-hearth plants built and building at the end of 1901 was 8,289,750 tons, which is nearly four times the largest output of open-hearth steel hitherto recorded for Germany, and nearly 160 per cent. in excess of the greatest output hitherto recorded for the open-hearth works of Great Britain.

The computed average annual capacity of the open-hearth furnaces employed in the United States is 18,500 tons. Of course the great bulk of the furnaces are of large size.

I have made an analysis of the open-hearth plants erected in the

State of Pennsylvania, which includes the Pittsburg district, and find that they stand in reference to their capacity as under :—

	Open-hearth Furnaces.
Under 20 tons	41
20 to 30 tons	80
30 to 45 tons	65
50 tons or over	79
Total for Pennsylvania	365

The aggregate capacity of the open-hearth plants in this State is approximately 8,840 tons, of which 3,950 are due to the 50-ton furnaces and 2,275 tons to the furnaces between 30 and 45 tons, leaving 2,615 tons for furnaces up to 30 tons. At the close of 1901 the new plants projected or being erected for the open-hearth process embraced 10 works in Pennsylvania, having a total of 51 open-hearth furnaces, of which 46 were of 50 tons capacity, and of which the total capacity was not less than 2,470 tons per heat. From this it would appear that in this State the open-hearth furnaces projected or in course of construction at the end of 1901 were equal to an increase of 28 per cent. of the total capacity of the plants then in existence. Two of these plants—the Union and the St. Clair—embraced severally 12 furnaces of 50 tons capacity, one other—the Central— six 50-ton furnaces, and two others—the Sharon and the Schuylkill—five 50-ton furnaces each.

Outside the State of Pennsylvania there are comparatively few 50-ton furnaces in operation. The only notable plants under this category are :—

	50-ton Furnaces.
The South Works of the American Steel and Wire Company...	4
Ensley Works of the Tennessee Company	10
Newburgh Steel Works, Ohio	4
South Works, Chicago	4
Total	22

But at the same date the Steubenville Works, in Ohio, were building ten 50-ton furnaces, the Inland Steel Company of Indiana were building four others, and the Diamond State Steel Company of Delaware were building five others at Wilmington.

Steel Castings.

There is no branch of the American steel industry in which greater progress has been made of late years than that of the manufacture of steel castings. The Directory shows that in April, 1898, there were 53 works carried on in the country that made, or professed to make, steel castings, but of that number the majority carried on this operation on a very small scale, so much so, indeed, that in the State of Pennsylvania there were only two firms with a capacity exceeding 10,000 tons a year, and only five others with a capacity between 5,000 and 10,000 tons annually. In the same year there were 20 works that under-

took the manufacture of steel castings in the State of Pennsylvania. At the end of 1901, this number had increased, with three works in course of erection, to 30. But the increase of output had been still more notable. The total recorded capacity for the manufacture of steel castings in 1898 by Pennsylvania steel works was 149,300 tons, and this had in 1901 increased to 334,000 tons. It is possible that in 1901 fuller particulars were obtained of the capacity of some of the plants than those recorded for 1898, but the margin of error likely to be due to this circumstance will not be very material.

Almost equally notable progress appears to have taken place in some other States. In Ohio the capacity recorded for 1898 was 31,200, and this had in 1901 increased to 123,450 tons; while in Illinois the corresponding advance was from 25,400 to 78,900 tons. In 1901, ten works in the United States had each a capacity exceeding 20,000 tons of castings a year.

The total capacity of the works engaged in the output of steel castings in the three States named increased from 149,300 tons in 1898 to 536,350 tons in 1901, being an increase of 387,050 tons, or 260 per cent., so far as the returns published enable a computation to be made.

Mr. Swank has ascertained that the number of plants in the United States that made castings in 1901 by the Bessemer, or by the Robert or other modified Bessemer process, was 13, while 56 other plants made open-hearth steel castings, 14 others made crucible steel castings, and four others made special steel castings.

A recently-developed feature of the steel-casting industry has been the increase of small plants, designed to enable steel to be melted in small quantities suited to that branch of manufacture, and regulated at will as to composition and other requirements. Various processes have from time to time been put forward as answering these conditions—among others the Clapp-Griffiths, the Walrand-Legenisel, the Robert, and the Tropenas. At one time, the Clapp-Griffiths appeared likely to have a good deal of vogue in the United States, but of late years that vogue has largely been lost. The Robert process reached its apogee in the year 1896, when three works carried it on, having five converters among them. In 1901 these figures were reduced to two works, with three converters, so that one works and two converters had dropped out. The Walrand-Legenisel process, which was introduced to the notice of the British iron industry by Mr. R. M. Daelen, of Düsseldorf, and Mr. G. J. Snelus, was introduced at one works in 1896, but has since then been abandoned. In the meantime the Tropenas process has been adopted, in a more or less modified form, at nine different works, and at the end of 1901 fifteen converters had been built to carry it on.

When one compares the actual output of the iron and steel works of the United States with their productive capacity, present and prospective, it is difficult to repress a fear that there are rocks ahead. These rocks may be disastrous to the United States, or to Great Britain, or to both. All that is certain is that the capacity of output is already greatly in excess of the probable demands of the United States, in every branch of the trade, as measured by the past records of consumption. To take only three cases, it would seem that the capacity for producing pig-iron is 50 per cent. in excess of the output of 1901,

immense and unprecedented as that year's make was; that the capacity for manufacturing rolled products is 140 per cent. in excess of the output of 1900 (the returns for 1901 are not available); that the capacity for producing steel ingots is 58 per cent. in excess of the actual output of 1901, although that year's output was 3,286,706 tons, or fully 30 per cent. in excess of the output of any previous year. The same conditions apply more or less to all other branches of the trade, as a glance at the following figures, which I have taken some trouble to compile from the records of the American Iron and Steel Association, will show.

Production in 1901.	Tons.	Annual capacity of U.S. at end of 1901. Tons.	Percentage capacity in excess of production.
Pig-iron	15,878,354	24 812,037	56
Bessemer steel ingots ...	8,713,302	12,938,000	48
Open-hearth ingots... ...	4,656,309	8,289,750	77
Crucible steel	100,562	175,000	75
Rolled products	9,487,443	23,220,350	145
Steel castings, open-hearth	177,491	400,000	126
Tinplates	302,665	63 works in all; 25 works have a capacity of 605,000 tons.	
Rails, all kinds	2,385,682	48 mills	—
Structural shapes	815,161	69 mills	—

The number of works engaged in the various departments of the trade were:—

	In 1898.	In 1901.
Puddling furnaces	3,251	3,889
Rail mills	48	51
Structural shape works	69	66
Plate, sheet and skelp mills	236	232
Tinplates	63	69
Cut nail and spikes...	43	46
Wire nails	68	79
Wire rod mills	37	24
Steel castings	79	53
Crucible steel	48	45
Open-hearth works...	124	99
Bessemer steel works	48	42

If these figures are to be accepted—as they are by the iron and steel industries of the United States as an approximately correct record of the existing situation, it would appear that the existing resources of production are as much in excess of the maximum actual output in the case of rolled products as in that of steel castings, where they are 126 per cent. in excess; and probably at least as much greater in the case of steel rails and structural steel as in that of rolled products generally. In all cases, the productive capacity of the works recorded includes that of the new plants actually in course of construction at the end of 1901.

In his Directory for 1898, Mr. Swank gives particulars of 87 works engaged in bridge building operations, whereas in his issue of the same valuable work at the end of 1901 he only gives the 25 works belonging to the American Bridge Company that are controlled by the

United States Steel Corporation, and names 67 works built and two building to roll iron or steel structural shapes. The capacity of the 25 works belonging to the American Bridge Company is stated at 441,200 tons, but as Mr. Swank found that there were 87 works prepared to undertake this business in 1898, these 25 works can only be regarded as comparatively much under the total bridge-building capacity of the country, although many of the plants named in the 1898 list had only a limited output.

At the end of 1901 there were in the United States 32 completed wire rod mills, with four building, one rebuilding and one projected, making a total of 38. The greatest output of wire rods from one mill in 24 hours was 262 tons, at the Rankin plant of the American Steel and Wire Company. At this rate, with 311 working days, such a plant may turn out about 81,000 tons of rods in a year, and if so ten such mills should be equal to producing all the wire rods produced in the United States in 1900—namely, 846,291 tons.

While the plant available was already largely in excess of actual requirements, if the figures which have just been submitted belonged to the statistical aspects of European plants, they would not greatly stimulate alarm or astonishment, because European conditions do not invest iron- and steel-manufacturing plants with such vast capacities as are usual in the United States. But American plants of all kinds are now worked under such wonderfully high pressure that each individual unit in iron and steel manufacturing plants means much more than it did only five years ago, and vastly more than it did ten years ago. A few examples of this fact may be quoted here as typical of the whole.

Let us first deal with the case of Bessemer steel-manufacturing plants. It is not by any means certain that the ultimate capacity of either a Bessemer or an open-hearth plant of a given number of units has been or can be stated. But "records" throw some light on the matter.

At the Edgar-Thomson Works of the Carnegie Steel Company four converters of 15 tons capacity have produced 3,000 tons of ingots in twenty-four hours. At this rate the capacity of this plant, if maintained for 311 working days, would be 933,000 tons a year, or one-seventh of the total Bessemer steel output of the United States in 1900. As only three converters are generally employed at one time in a 4-vessel plant, the actual work of producing the Bessemer steel ingot output of 1900 may thus be done by 21 converters, whereas the total number actually built in the United States at the end of 1901 was 81. Allowing one reserve vessel to each 4-vessel plant, the full number required on Edgar-Thomson precedents to produce the Bessemer output of 1900, which was 6,684,770 tons, would obviously be 26, or less than one-third of the total number in existence at the end of 1901. It is elsewhere stated that the output of Bessemer steel ingots in 1901 was 8,713.302 tons, whence it appears that the capacity of the converting plants was much more fully utilised in that year than in 1900.

The same remarks are more or less applicable to the plants engaged in the manufacture of open-hearth steel, which within a few

years have increased their capacity from 5,000 or 6,000 to nearly 20,000 tons per furnace per annum.

Next to blast furnaces, rail mills were among the first notable record-breakers of the United States, if, indeed, they did not come in front of the more elementary branch of the industry. The rail mills of the United States continue to make records that astonish and eclipse Europe. The total number of rail-mills in the United States is stated in the recently published *Directory of the American Iron and Steel Works* to be 45, with three building. And yet, the two rail mills at the Edgar-Thomson Works of the Carnegie Steel Company, near Pittsburg, recently produced in one month 61,000 tons of finished rails, which is at the rate of 732,000 tons of rails a year for this one plant. Assuming that this rate could be maintained, three plants, or six mills in all, might be able to produce the total steel rail output of the United States in 1900, which would leave but little for the remaining 39 mills to do.

On referring to p. 199 the same immense extent of capacity will be noticed in plate mills. Two mills at the Homestead Works of the Carnegie Steel Company produce an average of 36,000 tons per month, or at the rate of 432,000 tons a year, at which rate a very small number of mills should suffice to produce the total plate output of the country, and it may be noted that eight such mills working at the same rate of average output should be equal to producing approximately the full British output of plate steel in 1901. There is no authoritative record of the annual output of plates in the United States, nor of the exact number of plate mills, so that it is impossible to say what the output is in relation to capacity.

The same remark applies, *mutatis mutandis*, to other departments of the trade. Forgings, tinplates, black plates, hoops, sheets, and many other descriptions of iron and steel, have enormously increased in actual output, but have increased still more in capacity of output during the last few years.

The business done by the United States Steel Corporation for the twelvemonth ended March 31, included an output of 13,327,000 tons of iron ore, 9,079,000 tons of coke, 6,962,000 tons of pig-iron, 134,000 tons of spiegel iron, 57,000 tons of ferro-manganese, and 9,035,000 tons of ingots. The output of finished iron and steel included 1,676 000 tons of rails, 2,481,000 tons of blooms, billets, and slabs for shipment, 1,078,000 tons of wire and wire products, 1,236,000 tons of merchant steel, 743,000 tons of plates, 405,000 tons of tinplates, and 1,860,000 tons of miscellaneous iron and steel. The corporation's production of ingots was 67 per cent. of the entire American output. The average number of employés was 158,000, with a wages roll of not less than £22,565,400. The capacity of the works controlled by the corporation was, however, materially in excess of these figures.

The Steel Corporation manufactured goods, the selling price of which was approximately £91,800,000 and the cost £68,600,000. The net profits, therefore, amounted to £23,200,000; but from this amount must be deducted the cost of maintenance, £4,900,000, or 21 per cent., before the final profit is determined.

He would, nevertheless, be a bold man who would venture to set

limits to the future demands of the world for iron and steel. The boundaries of the use of these metals cannot possibly be fixed. Apart from its use in the manufacture of rails, the four main uses of steel at the present time may be said to lie in building ships, in making labour-saving machinery, in erecting buildings and bridges, and in railway car construction. A New York commercial journal has stated that in that city alone, in a single year, 125,000 tons of structural steel are used for building purposes outside of bridge construction, and it is well known that a single car company in the United States consumes 400,000 tons of steel each year in the making of freight cars alone. An interesting comparison has been made between the proportion of pig-iron used at various dates for the manufacture of steel rails and that left over for other uses. The result shows that while in 1879 the consumption for what is called "non-rail uses" was 75·4 lbs. per head of the population, in 1889 it was 213·2 lbs., and in 1898 it had risen to 276·2 lbs.

The *Railroad Gazette*, of New York, reported orders for 13,505 cars and 192 locomotives in one month of 1900, compared with 9,786 cars and 99 locomotives ordered in the corresponding month of the previous year. The economist or business man who takes the trouble to analyse the various sources of demand for iron and steel, and especially of such comparatively new sources as electrical plant and street railway equipment, will be likely to see that there are practically no limits capable of being assigned to this field, while the rapidity with which new uses have multiplied in the past justifies the anticipation of an increase in similar uses for the future.

CHAPTER XXV.

Some Final Facts and Considerations.

American Labour and its Remuneration.

THE conditions of labour, in respect to average and exceptional earnings, have already been referred to,* but this is a matter of so much importance that it will probably not be amiss to further deal with it in the light of information received more recently. The report of the United States Census on manufacturing and mechanical industries for 1900 shows that the average earnings of all classes engaged in the iron and steel industries of that year amounted to £117, against an average of £104 for the Census year 1890, being an advance of about 11½ per cent. Both these Census years were years of good trade, so that wages are certain to have been above the average of previous years in both cases. Nevertheless, that average does not probably come up to the general expectation of what it was likely to be, in view of the statements that have been published from time to time as to American wages.

Among these statements a prominent place should be accorded to two made at different dates by Mr. Andrew Carnegie. Some years ago, in naming the remarkable fact that 3 lbs. of steel were then being made for about 2 cents, that gentleman stated as follows :—

> "There is one element of cost, however, which every student of sociology will rejoice to know has not been cheapened, and that is human labour. It has risen, and the tendency is to higher earnings per man. In one of the largest steel works last year the average wages per man, including all paid by the day, labourers, boys, mechanics, exceeded 4 dols. per day--for 311 days. Fewer men being required, the labour cost per ton is less, and, contrary to the opinion often expressed, these men are of a higher quality as men. It is a mistake to suppose that men are becoming mere machines."

Again, in addressing his own workmen at Homestead, on the occasion of the dedication of a free library there in November, 1898, the same authority declared that in 1897 the average wages paid at these works, "man and boy, common labourer included," was 2 dols. 91 cents. per day, or 905 dols. for 311 working days. Now, there are two remarkable facts to be noted concerning these figures--the first that the 4-dollar-a-day rate is worked out to £249 per year of 311 working days, or considerably more than double the average annual wages found by the Census for 1900, which was a much better year of trade than 1898, and the second that the rate was 37 per cent. above the rate recorded for Homestead Works in 1898, although these works have always claimed to be at the top in the matter of highly-paid labour. I confess

*Cf. p. 54.

my inability to reconcile the 4 dol. rate and the 2 dol. 25 cent rate given by Mr. Carnegie, but, considering the fact that Mr. Dinkey, the present superintendent of the Homestead Works, recently gave the average wages paid there at less than either of these rates, I must conclude that the alleged 4-dol. rate calls for explanation.

According to figures furnished by the United States Census returns, the number of days of labour per ton of ingots at one British Bessemer works, was 9·47 per cent. greater, and at another 32·14 per cent. greater than in current American practice, while Trasenster found that in 1880 the United States produced 82 tons of steel ingots (both Bessemer and open-hearth), against 48 tons per workman in Belgium, the proportion of rails being in the former case 76 per cent., and in the latter 72·5 per cent. The records of the hands employed in individual works at the present time show greatly better results than these, and in the cases of the Edgar-Thomson and Duquesne Works, of which I have obtained details, more especially so.

At the Duquesne blast furnaces, which are each 100 ft. high and 22 ft. bosh, the blast pressure being 15½ lbs., and the temperature 1250° Fahr., the various groups of men employed were given me as follows :—

Hands employed at Duquesne Furnaces.

	No. of Hands.
Clerical and mechanical—clerks, fitters, blowers, moulders, etc. ...	45
Foremen, cranemen, coke weighers, labourers, sweepers, wheelers, etc.	100
Engineers, greasers, boiler house men, water tenders, helpers, ore men, water tenders, engine men, etc.	78
Telegraph operators, draughtsmen, master mechanics, police, etc., debited to blast furnaces	10
Machinists, machinists' helpers, millwrights, electricians, hydraulic workers, repair men	100
Riggers, sheeters, boiler-makers, etc....	30
Bricklayers	8
Transportation, loading, unloading, and reloading, brakemen, etc.	96
Construction men, engaged in new work	10
Total hands	477

The tendency in the American steel industry is to reduce by every possible means the number of highly-skilled men employed and more and more to establish the general wage on the basis of common unskilled labour. This is not a new thing, but it becomes every year more accentuated as a result of the use of automatic appliances which unskilled labour is usually competent to control. In 1890, Professor Howe pointed out* that "the average British Bessemer day's wage of 5s. 11¾d. (given by Sir L. Bell) is 113 per cent. above that of labourers, while at Mugby Junction (a typical plant whose identity is concealed) the average daily wage is only 64 per cent. above that of the lowest grade of labourers." In other words, according to this showing, 76 per cent. more of the labour employed in British works was skilled, and paid the wages of skilled labour.

* *Journal of the Iron and Steel Institute, II.*, 1890, p. 116.

Speaking generally, the cost of labour in American steel works, as represented by such works as the Edgar-Thomson and Joliet, is 2s. 4d. to 2s. 6d. per ton of ingots, or, stated in terms of labour, which may be taken as 10s. per day all round—assuming the figures publicly given by Mr. Carnegie and Mr. Dinkey for the Carnegie Company's plants—4 to 4½ tons of ingots are represented by a day's average wages in the largest plants. Since the open-hearth works increased the dimensions of their furnaces, and made use of electric cranes and charging machines, and other economies, the average cost of labour in the largest works is not much, if any, in excess of that found in Bessemer plants.

The average range of wages paid at the blast furnaces of the United States differs a good deal from the average paid at steel works, as the following figures for 1900 show in dollars :—

	Total Wages.	Average Wages per Employé.
Blast furnaces	18,484,400 ...	471
Steel works and rolling mills ...	102,238,692 ...	558

Here we have a difference of 87 dols. per annum, or nearly 19 per cent. more wages, paid to the men employed in steel works.

This difference is mainly a function of the higher range paid to particular classes of workmen, such as rollers and heaters. The American steel-manufacturer has succeeded of late years in largely reducing the relative numbers of his skilled and highly-paid hands, and much more than formerly is expected from them. As an example of this fact, I may refer to the Pittsburg works of the Pressed Steel Car Company, where I found three to four men, until lately quite unskilled, stamping out hydraulically fifteen "bolsters" per press per hour, and where men were attending to two boring machines at the same time, making themselves responsible for boring out 70 to 80 wheels per day per man, to the average depth of ⅞ in. Here the average daily wages exceed 10/-, although until lately the men employed were mostly agricultural labourers.

While firms in the eastern and middle States have greatly emancipated themselves from the thraldom of the trade unions, I found that at Birmingham (Ala.) this was far from being the case, and that the leading firms are almost at the beck and call of these organisations, which are increasingly aggressive. "We all recognise" said one of the leading ironmasters, "that some day we must prepare for a great struggle with the trade unions, who work here largely by boycott, and if their demands are not complied with, threaten to make it impossible for us to carry on our business. The strongest unions are those of the building trades."

Last year I wrote in a leading trade journal the following observations on American labour :—

"It has been assumed, and probably with a good deal of truth, that, speaking generally, the American labour attitude was that of individualism and the British one of collectivism ; that the American workman stood for himself and the British workman for his union ; and that, in the broad and abstract result, the American aimed at doing as much as he could, in order that his position might be as far as

possible improved thereby, while the British workman was held under the thrall of a system of which the fundamental and controlling principle is that the workman shall do as little as possible, or, at least, that there shall be a levelling down from the best to the worst capabilities of labour rather than a levelling up from the worst to the best. It is natural that those who have been inoculated with this faith in the differences that distinguish the labour conditions of the two countries should regard with apprehension the forthcoming tug-of-war. Naturally, the workman who does his best is always certain, all other things being approximately equal, to excel the man who does his worst, or even the man who is indifferent about doing his best. The issue is a matter of common knowledge. In all the mechanical industries, on which the industrial future of modern countries is so greatly dependent, the Americans have been rapidly annexing larger and larger sections of the field. American machine tools are now to be found in almost every engineering shop of importance, and with these tools British machinists should do as well as the Americans themselves; which may be taken to mean that the Americans would have little chance of competing with our engineering workshops were it not for the trade union fetish which ordains that the number of machines that a workman shall tend must not exceed a certain low limit—often not more than one—while no limit whatever is placed on the number of machine tools operated in American workshops.

Capital Outgoings.

Just at the time when the final sheets of this Report are being sent to press, I have received from the Census Office a bulletin containing the "Preliminary Results of the Twelfth Census of the Manufacturing and Mechanical Industries of the United States." From this it appears that the total capital embarked in the iron and steel industries in the two Census years 1890 and 1900 was as under—in thousands of dollars:—

	1890.	1900.
Blast furnaces	129,547	143,159
Rolling mills and steel works	275,347	429,960
Forges and bloomeries...	876	272
Totals	405,770	573,391

Here we have an increase between the two Census years of 41 per cent. the total capital embarked in 1900 being returned at about £115,000,000 sterling, which is considerably under the capitalisation of the United States Steel Corporation alone.

The Census returns show that the outgoings on the manufacturing of American iron and steel works in the year 1900, compare as under with those of the Census year 1890—in thousands of dollars:—

	1890.	1900.	Per cent. of total. 1890.	Per cent. of total. 1900.
Salaries	6,462	12,029	1·5	1·6
Wages	89,274	122,710	20·2	17·1
Materials...	327,273	549,127	74·2	76·6
Other expenses	18,215	32,510	4·1	4·5
Totals	441,224	716,376	100·0	90·8

These figures show that of the total cost of manufacturing iron and steel in the United States, the proportion falling to wages was 20·2 per cent. in 1890, and only 17·1 per cent. in 1900, being a decrease between

the two periods of 15 per cent., coincidently, as we have seen, with an increase of about 11½ per cent. in the average wages paid throughout those industries as a whole. On the other hand, the proportion of cost due to administration—salaried officials, clerks, etc.—has gone up from 1·5 to 1·6 per cent. of the whole, and the proportion due to materials has risen from 74·2 to 76·6 per cent. of the whole.

It is clearly likely to be useful to British manufacturers to institute comparisons between the figures just given on the authority of the Census, and those that are within the range of their own experience. Although many figures of this sort have passed through my hands at different times, I hesitate to build upon them any conclusions as to general results, knowing how dangerous it is to generalise from imperfect and possibly more or less exceptional conditions. But it will probably be found by those who may take the trouble to go into this question that in the manufacturing of iron and steel in Europe, the percentage of the total cost attributable to labour is materially in excess of the 17·1 per cent. shown by Census figures to apply to the United States, despite the fact that the nominal rates of wages take a considerably higher range in that country. Salaries are not likely to vary much as between Great Britain and the United States.

The American Steel Output.

The records of the output in the United States for the year 1901 are now complete, excepting only for crucible steel, and a wonderful story they tell. The total make of steel for that year was 13,369,611 tons, which is an increase of 3,286,707 tons on the output of the previous year. As the total output of pig-iron in the United States for the year 1901 was a trifle over 16 million tons, it may be taken, assuming a loss of 10 per cent., that about 15 million tons of the total output of iron would have been consumed in the steel industry alone, if pig-iron had been exclusively employed. But as a very large part of the raw material used in the open-hearth steel industry was scrap and ore, the actual consumption of pig-iron in this branch of the trade was much under the quantity of steel produced.

The figures of the two great departments of the American steel industry compare as follows :—

	1900. Tons.	1901. Tons.
Bessemer	6,684,770	8,713,302
Open-hearth	3,398,135	4,656,309
Total...	10,082,905	13,369,611

It will be noted that in 1900 the output of open-hearth steel was a little over one-half of the total output by the Bessemer process, while in the year 1901 the output by the open-hearth process was nearly half a million tons in excess of a moiety of the whole. This confirms the prevailing idea that the open-hearth is making greater progress than the Bessemer process. At the same time, it must be admitted that an increase of 2,028,532 tons in one year, which is the record of the Bessemer process in 1901, is not much evidence of an expiring, or even of a

seriously declining, system. The two processes, indeed, have in the United States different fields which have more or less definite lines of demarcation. The Bessemer process almost holds the field for rails of all kinds, and to a large extent also for structural steel. The open-hearth process has its sphere in the manufacture of plates, sheets, tin-plate bars, wire rods, forgings, and, to some extent, in castings, not to speak of many minor purposes. In some cases open-hearth steel is used for tubes, and in other cases—as at the National Tube Works, at McKeesport—Bessemer steel is largely used in this branch of industry. There appears to be no general consensus of American opinion in favour of the open-hearth as against the Bessemer process. But there appears to be a probability that limitations will, in accordance with American practice, be placed on that process by the extent of available future supply of Bessemer ores, which are already relatively scarce and dear. There is, of course, no reason why basic steel should not be made by the Bessemer as well as by the open-hearth process, as it already has been at Troy and one or two other works, and as it is now in this country at the North-Eastern and the Cleveland Steel Works on the Tees-side, as at Glengarnock, in Scotland, at the Staffordshire Steel Works of Sir Alfred Hickman & Co., and at the Leeds Steel Works. But the metallurgists and manufacturers of the United States appear to have made up their minds that the open-hearth process is better suited to the use of basic ores, and the tendency of the present time is to employ such ores almost exclusively in open-hearth practice. The output of basic steel in 1901 by that process was 3,618,993 tons, against 1,037,316 tons by the acid process, so that nearly 80 per cent. of the total open-hearth output is basic steel. As might naturally be expected, the bulk of this basic steel output is founded on the Mesaba ores, and is produced in the Pittsburg district. Indeed, 78 per cent. of all the open-hearth steel output of the country is made in the single State of Pennsylvania, which includes not only Pittsburg, but Philadelphia, Harrisburg, and other important centres of trade, while Illinois comes next with nearly 9 per cent. of the whole, the bulk of which is produced in and around Chicago.

To compare the British steel output with that of the United States is naturally not to magnify the importance of the British steel industry. That industry has not yet published its returns for the year 1901, but they are likely to be in the neighbourhood of 1,760,000 tons of Bessemer steel ingots, and of 3,250,000 tons of open-hearth steel ingots, or 5,010,000 tons in all, which is just about 27 per cent. of the total of the two countries. Until 1900 the British open-hearth output was greater than that of the United States. Now the United States are leading by more than a million and a quarter tons a year. In the output of basic steel, as such, the lead of the United States is still greater, and amounted in the open-hearth category to fully seven times as much as the British production.

What is the United States likely to do with its vast steel output and its capacity for a production ever so much greater still? The fact that the capacity of the American Bessemer and open-hearth steel works at the end of 1901 was 58 per cent. in excess of the output of steel in that year, including works then being constructed, appears to promise

a much greater output in the future. That capacity is returned by the American Iron and Steel Association at 21,227,000 tons a year, which is about three million tons a year in excess of the largest recorded output in a single year of all the rest of the world, and nearly four times the output of steel by both processes so recently as the year 1896. The world's demands for steel have increased rapidly, and now truly amount to a very considerable figure; but, that fact notwithstanding, it would almost appear to be impossible that the United States could consume anything like their present capacity, or even their present actual rate of output, under normal and ordinary conditions. What, then, will happen? Either the output must greatly decline, as did the output of both pig-iron and steel between 1890 and 1895, or the steel manufacturers of the United States must deluge the world with steel, at prices that are not likely to be greatly remunerative, in the not far distant future.

British versus American Conditions.

The allegations of British backwardness and want of enterprise are not justified to anything like the extent that some notable pessimists suppose. There are in Great Britain, to my knowledge, finer works in many branches of engineering than are to be found in the United States. America has probably no counterpart worthy to rank with the works of Armstrong, Whitworth & Co., whether at Newcastle-on-Tyne or at Manchester. This, however, is hardly a concern that is typical either in its markets or in the character of its productions. There are others. What American works can compare in their own special line with the works of Platt, at Oldham, and the works of Howard & Bullough, at Accrington? What American tube works are better organised than those of Stewart & Menzies, at Glasgow, apart from mere size? What pipe foundries excel those of the Staveley Company? What pump works can claim to be more up to date than those of Messrs. Joseph Evans & Sons, at Wolverhampton? What locomotive works are better equipped than those of Neilson & Dubs, at Glasgow? And so in many other branches of the iron and engineering industries.

Not only can Great Britain make claims for her principal works, such as those referred to, but those claims are likely to be emphasised by the new plants now being constructed to deal with those industries enumerated. The new works of the Westinghouse Electric Company, at Manchester, or of the Thomson-Houston Company, at Rugby, are cases in point; and at Rugby, also, are the magnificent new engine works of Willans & Robinson, of which it may at once be said that it would be hard to go one better. Most of our great industrial centres can claim similarly model establishments. Those we have named are only put forward as types—not, of course, of the rank and file, but of the best of their kind, although they are far from being alone.

Then, again, what lack of enterprise is shown on the part of the leading firms in the steel trade who have taken up the Talbot and Bertrand Thiel processes? At the time of my visit to the States only one firm had actually started the Talbot process, and none that I heard of had essayed the other. A second Talbot furnace was then being erected. In this country, the Frodingham, Dowlais, and Weardale

Companies are adopting the Talbot process, and I am informed that two other firms are proceeding to instal the rival process, while the Monell process has also been adopted on Tees-side.

The conclusion to be drawn from the recent attitude of British iron and steel manufacturers in regard to new improvements, appears to me to be favourable to the future of those industries. Probably no authorities have taken greater pains to inform themselves as to that future, as liable to be influenced by American competition, than those who have been concerned in the recent consolidations in South Wales. Have these gentlemen sat down and folded their hands despondingly? Have they not been stimulated by what they saw and learned in the United States to take steps which implied a large amount of confidence in the future? And is not the same inference justified by similar action on the part of many other leaders of the trade, including those responsible for the destinies of that almost historic corporation—the Weardale Steel, Coal and Coke Company?

I think there is some reason for believing that British manufacturers sometimes, and perhaps frequently, adopt rather pessimistic views of circumstances that their American rivals would deem not unfavourable. Take, for example, the case of the Cleveland district (North Yorkshire). In a letter sent in July, 1901, to the *Iron and Coal Trades Review*, Mr. A. F. Pease, of Darlington—a director in the firm of Pease & Partners—argued that the supply of best ironstone in that district was limited to from 60 to 70 million tons, and that the life of this description would not be likely to exceed seventeen years at the then rate of exhaustion, although there are practically unlimited supplies of "shale" ironstone, varying from 25 per cent. to 29 per cent. of iron, on which in the future the furnaces producing Cleveland iron must mainly depend. Mr. Pease made this fact the basis of a calculation which resulted in showing that the cost of producing Cleveland iron could not be expected to fall below £2 4s. 8d. per ton, but his figures assumed the cost of coal per ton of coke to be 5s. 6d., whereas official returns show that it has for long periods been under that amount; that 60 per cent. was the yield of coke per ton of coal, whereas by-product ovens are stated to yield over 70 per cent. and to give by-products worth 1s. 6d. to 2s. 6d. per ton in addition; that 24 cwts. of coke per ton of pig was necessary, which is hardly in accordance with recent theories of calorific value; that 1s. per ton of pig had to be expended on coal at the furnace; and that 7s. per ton was the irreducible minimum cost per ton of pig for wages, standing charges, salaries, and repairs. The attitude adopted by American ironmasters in such circumstances may be typified by a statement recently made by Mr. C. Kirchhoff, of the *Iron Age*, who, after going over some of the leading mines and works in the Cleveland district, declared that under favourable conditions pig-iron could be made there for about 30s. per ton—as, indeed, I am correctly informed, it has been in the not very remote past. I would not for a moment presume to suggest that the ironmasters of Cleveland require the guidance of any outsiders in the conduct of their affairs. That is a very different matter from an attitude of mind as to the future, which, if unduly indulged, may tend to indispose those who hold it from making the most that is possible of their conditions.

Continental Conditions.

Having said so much as to the aspects presented by a comparison of American and British conditions, it may be interesting if, before closing this Report, I say something as to the comparative circumstances of the most important centres of the iron industry of Continental Europe. These are Alsace-Lorraine and Luxembourg, which, with the district of the Meurthe-et-Moselle, situated close by, produce almost as large a volume of iron ore as that raised in the Lake Superior region. No other part of the world presents a counterpart to the advancement of the United States equal to that of this notable region. Such has been the appreciation of the resources of this centre, that in Alsace-Lorraine the value of the concessions of iron ore has greatly improved during recent years, as elsewhere. According to a recently-published statement, the value of a hectare* of iron ore lands on the plateau of Aumetz was £50 to £75 about 1892; £125 to £150 in 1894; £250 in 1896; and £500 in 1899.

It is estimated that there are on the plateau of Aumetz 12,198 hectares of iron ore lands available, of which some 3,585 hectares, which constitute the prolongation of the bearing of Esch-sur-Alzette, contain about 250,000 tons of ore per hectare, or about 896 million tons in all. Assuming that the remaining 8,613 hectares contain 100,000 tons per hectare, the total quantity left on the plateau of Aumetz would work out to 1,757½ million tons, and it has been computed that the other iron ore deposits found between the plateau of Aumetz and that of the Orne contain 725½ million tons more, which supports the conclusion that the entire iron-bearing region of German Lorraine, extending from the north of the Orne to Luxembourg, can furnish a total of 2½ milliards (exactly some 2,483 million tons) of iron ore, varying from 28 to 35 per cent. in metallic richness, and often running to a thickness of four metres. These are all metrical tons of 2,204 lbs.

The whole of the most valuable of the ascertained ore lands have already been taken up by three groups of proprietors. The first, known as the group of Belgian, French, and Luxembourg owners, had, at a recent date, acquired 2,963 hectares; the second, the owners of German works on the Saar and the Moselle, had acquired 19,701 hectares, and the third, the group of owners of works on the Rhine and in Westphalia, had acquired 7,060 hectares. This left about 11,0[illegible] hectares to be divided among owners who were not also ironmasters, and who, in some cases, had taken up the concessions for merely speculative purposes.

The Minette ore district of Lorraine and Luxembourg has made very rapid progress during recent years. In 1872 the total output of this region, including Luxembourg, was only 2,865,000 tons. In 1890 this output had been increased to nearly 8 millions; in 1895, to 11[illegible] millions; in 1899, to about 17 millions; in 1900 to about 18[illegible] millions. Excepting the Lake Superior region, therefore, this is the greatest iron ore producing region in the world. The average value of the ore output of this region at the place of production is about 2s. 3d. per ton.† Assuming the average

* A hectare is equal to 2·47 acres.

† In 1900 the official values were 2·87s. for Lorraine, and 2·24s. for Luxembourg, but both were above the average in that and the two previous years.

content of the ore to be 32 per cent. of iron, this would give an average of 0·84d. per unit at the mine. This is probably the lowest price in Europe for ores produced on a large scale, and it compares most favourably with the value of the iron ores furnished by the Lake Superior ranges, the average of which for the year 1900 I have ascertained from Mr. Swank's Report to have been about 20s. per ton delivered at Cleveland, on Lake Erie, whence the average distances to the blast furnaces will not be greatly different to that traversed by the ores produced in Lorraine and Luxembourg, although the American rates of transport are below any known in Europe on a large scale.*

The Lorraine region, like the Mesaba range on Lake Superior, can, and does, yield very cheap ores. The Mesaba ores have been mined for 10 to 15 cents per ton, and even less; and in Lorraine the cost of tunnel-mined ores has been as low as 10d. per ton. The cost of producing pig-iron with the conditions appertaining to these two regions and that of the Cleveland district in England, may be computed from the fact that the Minette ores of Alsace and Luxembourg per ton of pig-iron cost only about 6s. at the mine, against 10s. 6d. to 12s. for Cleveland ores, and 12s. to 20s. for Lake Superior ores, similarly estimated. The conditions of assemblage at the blast furnaces differ greatly. In the Cleveland district the cost of assembling the ores varies from 5s. to 6s. 6d. per ton of pig; in Alsace-Lorraine the cost varies from 7s. 9d. for furnaces near at hand, to 21s. for furnaces in Westphalia; and in the United States the Lake Superior ores, as we have seen, cost for transport to Pittsburg, the chief centre of consumption, from 8s. to 12s., according to the period and location. The Cleveland district is, however, nearer to the fuel supplies than any other district of equal importance, although some blast furnace plants near Saarbrück run Cleveland pretty close.

So far as Luxembourg is concerned, the quantity of iron ore assured to the furnaces actually in existence, was computed in 1898 at 135 years, or a total supply of 177 millions of tons, assuming an average of 100,000 tons per hectare. The selling price of ore at the mine varies from 1 franc 80 cents to 3 francs per ton, in normal time (say 1s. 9d. to 2s. 6d.).

The variations in the value of iron ores, apart from those of foreign origin, are considerably greater in the case of the United States than in the Cleveland district, or the districts of Alsace, Luxembourg, and the Meurthe-et-Moselle.

The Foreign Trade Outlook of the United States.

The attitude of American manufacturers in relation to the British markets of the near future may be regarded as typified by the following extract from a recent article in the *Bulletin* of the American Iron and Steel Association, referring to an article that had appeared in the *Iron and Coal Trades Review* of March, 1902, in which the progress of improvements in British iron-making and steel-manufacturing plants was referred to:—

* I have taken the year 1900 for both Lake Superior and Lorraine ores, but in that year the value was materially higher than in either 1899 or 1901.

"The above article," it was remarked, "is worthy the serious attention of American iron and steel manufacturers. It will be only a few years, possibly only one year, until our British competitors will have many furnaces built and operated upon American lines. With their cheaper labour there will then be little room in British markets for American pig-iron, and in neutral markets our pig-iron makers will have sharper competition than they have recently had. And Germany, too, will have a hand in this competition. Its pig-iron manufacturers have already studied and copied our best furnace practice. And so of other branches of iron and steel manufacture. Europe will not long content itself with the old and expensive methods. Our people simply deceive themselves if they think that the world's markets for iron and steel are hereafter to be within their grasp. The activity in our export trade in iron and steel in the last few years was exceptional and abnormal and cannot be continued. Not only will Europe adopt our methods but it will always have cheap labour. Again we say, as we have frequently said, that the home market is our best market and that it should be carefully guarded. Whoever says that our iron and steel industries no longer need protection does not realise what fierce competition in our own markets a reduction of even 50 per cent. in our iron and steel duties would bring. He is helping the free trade enemy to break down needed protection."

The Editor of the *Bulletin* of the American Iron and Steel Association, referring to the fact that in the eight months ended with and including February last, the American imports of iron and steel had increased from 110,830 tons to 197,138 tons, while the corresponding exports had decreased from 861,583 tons to 353,202 tons, remarks that these figures "are of great significance. The reader will note the great increase in our imports of iron and steel in these eight months and the very great decrease in our exports in the same period. Imports increasing and exports decreasing rapidly, and yet there are good people who think that 'it would do no harm' to reduce or wholly repeal our iron and steel duties. It would certainly 'do no harm' to European iron and steel manufacturers."

During my stay in the United States, I found that the iron trade generally was giving very little attention to foreign business, and that no one appeared to think that there would be iron or steel to spare for export for at least twelve months to come. This anticipation has so far been realised during the year 1902. Not only have American manufacturers been unable to provide for home needs, but they have been compelled to import considerable quantities of pig-iron, billets, and other products from Europe, and it is regarded as probable that this demand for foreign products will increase. It is believed that in the first three months of 1902 the consumption of the United States has been at the rate of 17 million tons of pig-iron per annum, or nearly three times the actual rate of consumption in the year 1894.

Through Bills of Lading.

In the path of reform a matter of not inconsiderable importance is the facilities which the American exporter possesses, and which the British exporter ought to possess, for through bills of lading. The Merchants' Association of New York, with whom we had a useful consultation, informed us that they found these facilities most valuable in enabling them to quote the exact cost at which any particular consignment could

be delivered at any particular port in almost any part of the world. The machinery provided by railroads and transportation companies in the United States for thus simplifying international transactions appears to be very complete, and it possesses obvious advantages over what I believe is the general system practised in Great Britain of making quotations f.o.t. at works, or f.o.b. at ports, or at the best c.i.f. at a foreign port, whence the remaining freight has to be ascertained for himself by the consignee.

Duration of Boom of 1898-1900.

It is of importance to the iron trade on both sides of the Atlantic to be able to diagnose as far as possible the duration of the present boom in the American iron trade. Such diagnosis, however, cannot even be attempted without a preliminary ascertainment of the causes of the boom. Is it chiefly due to the increasing substitution of steel for other materials —such as steel for timber in car and in building construction? Or is it due to the expansion of the railway system on an unprecedented scale; to the growing needs of general industry in such large sources of demand as pipe lines, electrical equipment, and kindred uses? Whatever the main sources of this extraordinary demand may otherwise be, it is important to bear in mind that a large part of it is due to the activity recently and at present prevailing in equipping new plants and old for an extended scale of production—not in the iron and steel industries only, but in every other branch of mining and manufacture. Can this phenomenal expansion of industrial resources proceed much farther without a check? That is the problem, the solution of which is of most immediate and most anxious concern.

Closely allied to this problem is the equally pressing, and, to Great Britain at all events, engrossing problem of what is likely to happen when the boom of the last three years has come to an end? We shall then be likely to witness such a battle of giants as probably never before has taken place in the records of industry. It is difficult to believe that the United States in times of depression can find employment for much over one-half of the vast productive capacity which has been described in these pages, and that now being provided for. This conclusion is fully justified by the experience of the past. We are apt to forget that it is not more than eight years since the pig-iron consumption of the United States fell to little over seven million tons a year, or considerably less than one-half of that of to-day. If a productive capacity of 24,000,000 to 26,000,000 tons of pig-iron were brought face to face with a demand for only one-third of that quantity, with a corresponding relation of demand to capacity in all other branches of the iron and steel industries, some strange things would be likely to happen.

It will, of course, be understood that when the capacity of the iron and steel works of the United States is referred to, it is not intended to imply that there is any chance, under any conceivable circumstances, of that capacity being fully utilised at the same period. In all iron-making countries there is always a certain, and in most cases a considerable, proportion of the existing plant that neither is, nor can be, utilised for a

variety of causes. In the particular case of the United States, as, indeed, would happen in our own country, the full capacity of the pig-iron making plants is always subject to a reduction of at least 10 per cent. for plants undergoing repairs or reconstruction, and then there is always more or less uncertainty as to the available supply of iron ores, which are not unlimited in any country—not even in the United States. At the same time, it need hardly be added that the plants of the United States were never in such a generally high condition of efficiency as they are to-day. The ineffective and uneconomical plants have been rapidly and largely eliminated during recent years, so that none can now hope to maintain its ground unless it has some claims to be up to date, and least of all in the centres that have alone been deemed entitled to consideration in this Report.

Output in Relation to Hands Employed.

The output of iron and steel relatively to the number of hands employed in the American iron industry can be approximately computed from the Census returns, and a very interesting record it is. For the year 1900 the average output of pig-iron per man employed at the blast furnaces was 354 tons, while for the year 1890—the year when the Iron and Steel Institute visited the United States—the average output of pig-iron per worker was 275 tons, showing between the two periods an increase of 79 tons. This, however, is a small advance compared with that realised in some individual cases. At the Duquesne Works of the Carnegie Steel Company, for example, I ascertained from Mr. Hunt, the general superintendent, that the total number of hands employed was 477, and as the capacity of the blast furnaces is fully 620,000 tons a year, the average annual output per employé at the furnaces comes out at about 1,300 tons.

The Census returns make it clear that while between 1890 and 1900 there was an increase of 79 tons, or about 29 per cent. in the average output of pig-iron per employé, at American blast furnaces, in the same period there was an increase of approximately 37 per cent. in the average output of rolled products—finished iron and steel of all kinds, (including rails) passed through rolling mills, which practically means all the finished iron and steel produced except such relatively small quantities as are used in the manufacture of castings, or other products not rolled.

Increase in the Size of Plants.

The increase in the average dimensions of the American iron- and steel-making establishment is patent to all who have taken note of the recent progress of that industry, but the facts are brought home to us in a more or less concrete form by the Census figures, which show that in 1890 the average capital expenditure on each of the 719 establishments then engaged in those industries was 563,000 dols., whereas in 1900 the average of the 725 similar establishments recorded for the country as a whole was 800,000 dols., being an average increase of 42 per cent. within the ten years' interval.

This increase in the average capitalisation of the iron and steel works of the United States clearly implies that in the future it will be increasingly difficult for men of limited means to embark successfully in the iron trade of that country. If the tendency to increase the dimensions of such works should continue, there will be likely to go along with it the conjoint movement of concentration of plants, which must ultimately place the control of the trade in fewer hands. This process accords with all the teachings and experience of political economy. Every economist, from the days of Adam Smith onwards, has inculcated the advantages of production on a large scale. In the United States it is likely to become the fundamental law upon which not only success, but very existence is founded.

It may be said that such concentration as would deprive the man of modest means from being able to engage in manufacturing industry, must still be a long way off, when there are now 725 establishments in the United States engaged in the iron and steel industries. But many of these establishments are in out-of-the-way localities, and engaged only in providing for local wants, while another large proportion is controlled by one or other of the half-dozen or so of consolidations, like the United States Steel Corporation, which have already done so much to accentuate the movement towards larger units of production.

Some Local and Municipal Conditions.

The social and municipal surroundings of the industrial centres of the United States generally leave a good deal to be desired. Take Pittsburg as a case in point. Here the water supply is very bad, as it is also in Philadelphia, and in most of the other large cities. Good water supply is an exception. Bridges, essential to the convenience of everybody, are often in the hands of private parties. Railway companies possess franchises which enable them to run their trains through the principal streets, to the obvious detriment of public interests. Generally speaking, the condition of the streets in regard to paving and cleanliness is utterly bad. The drainage is usually more or less imperfect. Municipal administration is neglected by the most capable and distinguished men. Learned leisure is almost unknown. The man who is not actively engaged in business is apt to be regarded as a loafer. For many the pace is too hard. Allegheny City, which is practically Pittsburg, is notorious for the large number of cases of self-destruction, and is known as "the Suicide City." All this has to be offset against the higher wages and more comfortable conditions of living which American workmen generally enjoy.

In a good many cases, also, the working men have to put up with poor dwellings, unsanitary surroundings, unhealthy factories, and conditions generally that do not make for comfort. But a higher ideal is in many cases being set up by both employers and workmen, and in some cases has been realised. I have seen no workman's city in Europe nearly so perfect as Vandergrift, although I have examined Krupp's Colonies at Essen, Pullman's model town near Chicago, Saltaire in England, Creusot in France, Menier's Workmen's Colony near Paris, and similar

model communities elsewhere. Here water supply, sanitation, the laying out of the landscape, the character and arrangement of the workmen's dwellings, the means of wholesome recreation, the absence of temptations to insobriety and vice, and the aid afforded to the leading of healthy, self-respecting lives, are all more or less unique. And I have noted that the splendid example set by my friend Mr. George G. McMurtry at Vandergrift, has been, or is being, more or less followed elsewhere, the latest example of the kind being that of the Steel Corporation, which, in offering a large area of land near the Homestead Steel Works, at Pittsburg, for building workmen's dwellings, have laid down rules designed to make a model community, including the provision that the houses shall be of a certain size and built in conformity with regulations adapted to secure comfort within and a good appearance without, while the sale of spirituous liquors is entirely prohibited.

SECTION XII.

CHAPTER XXVI.

The Canadian Iron and Steel Industries and Canadian Competition.

The Dominion Iron Company.

ALTHOUGH Canadian works and operations were not included in our terms of reference, I have thought that it would hardly be consistent with a reasonable presentation of the facts of foreign competition if we omitted all mention of the new iron industry that has recently come into existence in Nova Scotia, mainly through the enterprise of the Dominion Iron and Steel Company. Many different and widely con-

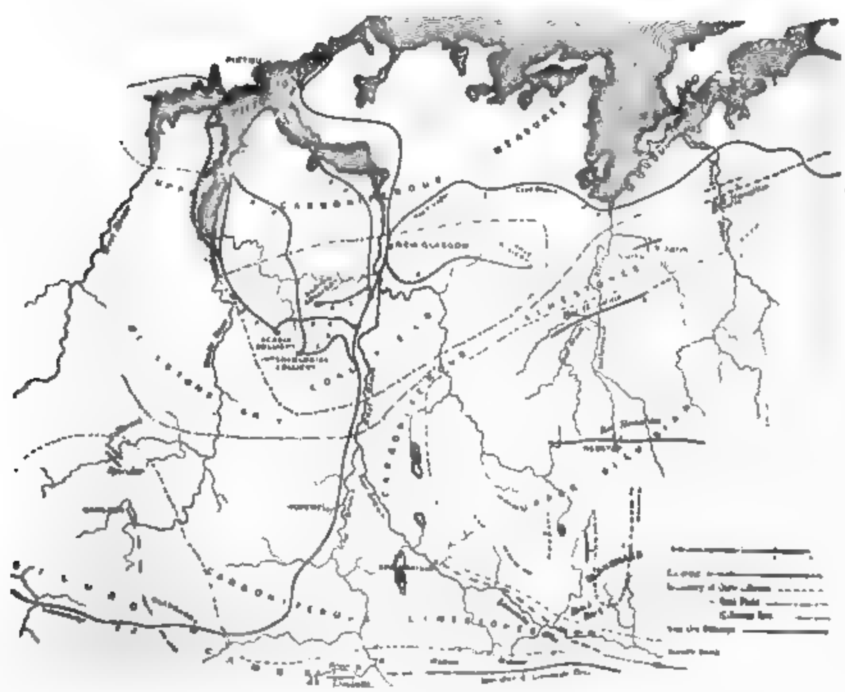


FIG. 75.—SKETCH MAP SHOWING IRON ORE AND COALFIELDS, PICTOU COUNTY, N.S.

flicting statements have been made as to the low costs at which this company can manufacture both pig-iron and steel. The company possess coalfields in Nova Scotia, and iron ore fields in Newfoundland, and the cost of mining and assembling the raw materials is no doubt unusually low. Mr. Moxam—the joint promoter with Mr. H. M.

Whitney, of this great enterprise—has estimated the cost of producing pig-iron at the company's works at Sydney, C.B., at 5 dols. 50 cents, or 22s. 11d. per ton, of which he assigns 1 dol. 80 cents severally to the ore and the fuel, and 1 dol. 50 cents to labour, repairs and incidentals. The cost of steel blooms is estimated on the same authority at 11 dols. 25 cents per ton, or 47s., which is materially under any estimate I met with in the United States, and which I should venture to regard as below the figures likely to be averaged over a term of years.

The Recent Growth of the Iron Industry of Canada.

Canadian iron has been a plant of extremely slow growth. It is now nearly fifteen years since I was first waited upon, in London, by a Canadian gentleman, who had acquired a number of coal lands and iron fields in Pictou County, Nova Scotia, with the object of establishing a large company to carry on the manufacture of iron and steel. He made a vigorous attempt to found such a company, got up a prospectus, secured promises from several well-known capitalists to act as directors, and appeared otherwise likely to succeed in his aims, when a check occurred and thwarted all his plans, so that the company never saw the light. The progress made since then was until the year 1900 inconsiderable. Five years ago the total output of Canadian pig-iron was only 37,829 tons. In the same year the total output of Canadian steel was only 16,000 tons.* For some years past there has been a limited output of steel rails, which reached 700 tons in 1900. The other productions in steel are structural shapes, cut nails, plates and sheets, and billets.

In 1900, the start made by the Dominion Company, and by one or two other concerns, induced a considerable increase of output of both pig-iron and steel. In the first half of 1901, the output of pig-iron was 95,024 tons, which was more than the total output of any previous year. The total production of steel in the same period is not known, but the make in 1900 was 23,577 tons.

At the end of 1900, there were 10 completed furnaces in Canada. At the present time there are 14, including the four erected by the Dominion Company. These four furnaces are estimated to be equal to an output of about 500,000 tons a year.

The total number of rolling mills and steel works in Canada at present is 18 completed, and two in course of construction.

The total capacity of the blast furnaces now built, or being built, in Canada is estimated by Mr. Swank at 1,090,000 tons, or more than twenty times the output of pig-iron in the Dominion five years ago. The total capacity of the rolling mills is estimated at 981,000 tons; of Bessemer steel, at 361,400 tons; of open-hearth steel, 537,000 tons; and of steel ingots and castings, 838,000 tons.

This remarkable development is one that the iron trade of Great Britain cannot afford to ignore—especially in view of the fact that the total present consumption of iron and steel in Canada is not quite half a million tons.

* These and other figures are given on the authority of Mr. Swank's Annual Reports to the American Iron and Steel Association.

The iron ore resources of Canada, whatever they may be worth, are clearly, as yet, almost virgin in character. When I visited the Dominion in 1890, in charge of a contingent of the Iron and Steel Institute, I had the opportunity, at a banquet given to us in Montreal,

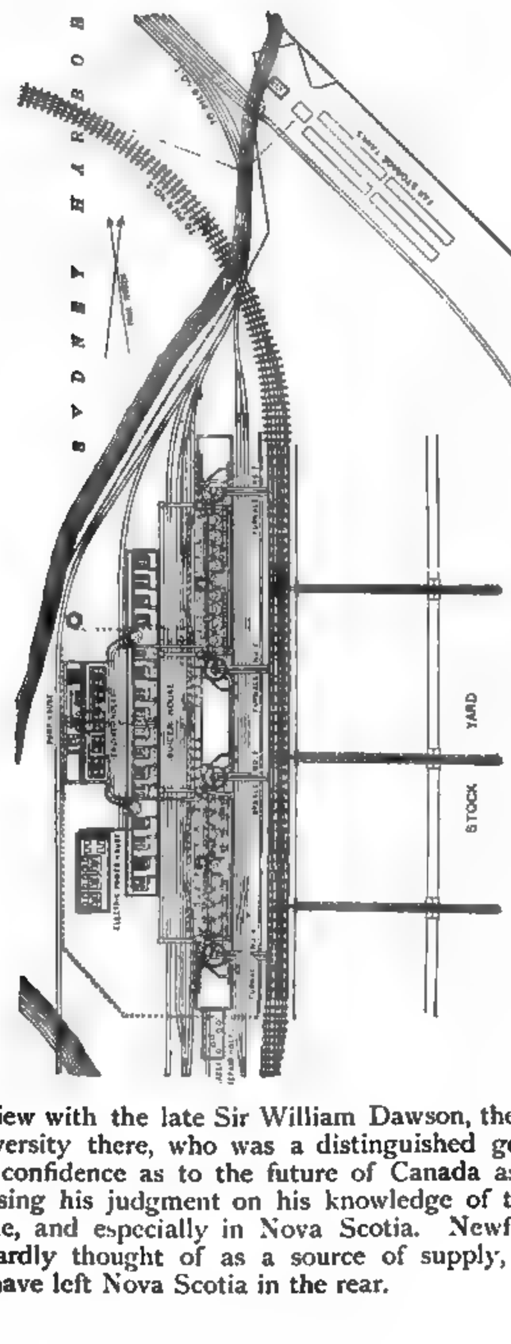


FIG. 76.—PLAN OF BLAST FURNACE PLANT OF THE DOMINION IRON AND STEEL COMPANY.

of an interview with the late Sir William Dawson, the principal of the McGill University there, who was a distinguished geologist, and who spoke with confidence as to the future of Canada as an iron-making country, basing his judgment on his knowledge of the coal and iron ores available, and especially in Nova Scotia. Newfoundland at that time was hardly thought of as a source of supply, although it now appears to have left Nova Scotia in the rear.

The Belle Island Iron Ore Supplies.

It is claimed that the ore mined in Newfoundland will not in ordinary circumstances cost more than 2s. 3d. to 2s. 6d. per ton, to which from 1s. 6d. to 2s. per ton has to be added for transport to Sydney. The coal, which is cheaply mined, is found close to the works at that town, where

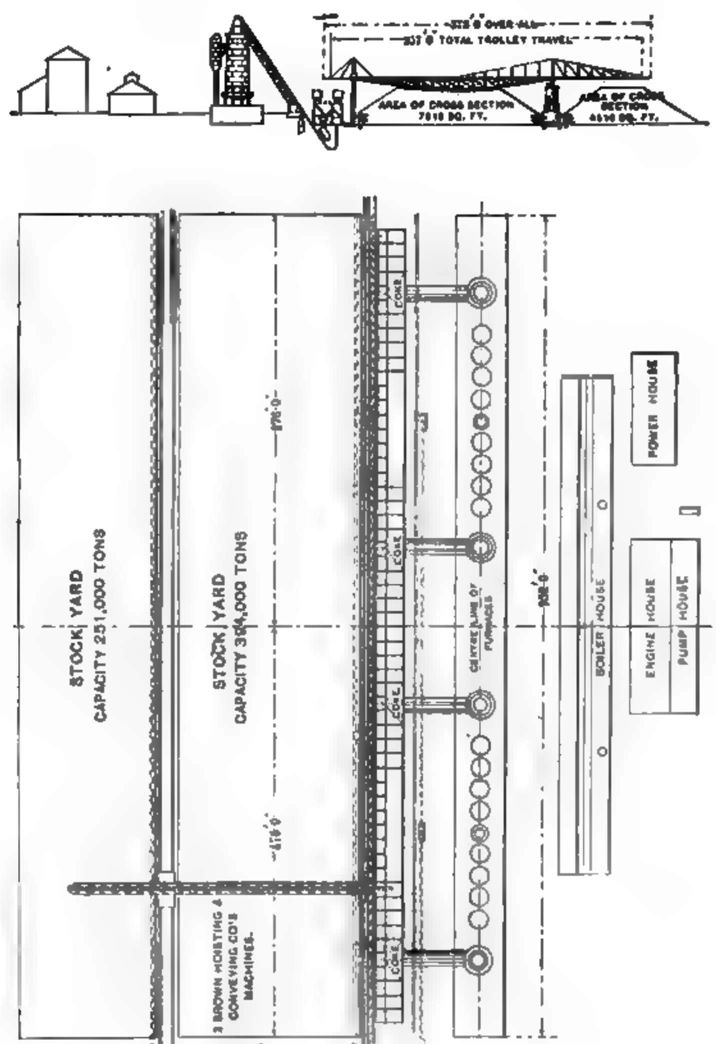


FIG. 77.—FURNACE PLANT AND STOCK YARD AT DOMINION COMPANY'S WORKS.

the company are said to control 2,500 million tons. The coke is estimated to cost 6s. 3d. per ton at the blast furnaces.

There is as yet but a very limited market for the products of the Dominion Company in Canada itself, and the company therefore look to finding their chief markets in other countries. A good deal of pig-

iron has already been shipped to Great Britain, and it is probable that this trade will be extended in the near future.

The important iron ore deposits of Belle Island are in Conception Bay, 2½ miles from the shore. These deposits consist of four horizontal beds. The two uppermost beds are relatively mere shells, but the third, about 6 ft. in depth, underlies an area of 240 acres. The fourth, 8 ft. in depth, has a land area of 817 acres. Based on 10 cubic feet of ore to the ton, these two beds have been computed to contain some 34 million tons of ore, which assay 54 to 56 per cent. of metallic iron, ·47 to ·70 per cent. of phosphorus, and 6·4 to 9·4 per cent. of silica. Such computations, however, generally err on the side of over-estimation.

The two main beds of ore, known respectively as the lower and the upper beds, lie about 200 ft. apart, measured vertically, and dip northward at angles of 6 degrees to 8 degrees from the horizontal. The outcrops occur at an elevation of 200 ft. above sea level. The length of the lower bed outcrop is 3½ miles, and of the upper bed 1½ miles. The thickness of the upper bed is 5 ft. of good clean ore, with no rock parting. The lower bed varies in thickness. At the centre mine there is an overlay of 1 ft. 6 in., 6 to 9 ft. of ore, and after 12 to 18 in. of rock another 4 to 6 ft. of ore. At the east mine there is 4½ ft. of ore under 6 in. to 3 ft. of overlay.

The ore is mined by steam drilling a series of 10 to 12 1¼-in. holes, about 6 ft. apart, to the depth of the bed. These are loaded with 40 per cent. dynamite and fired simultaneously by a battery, thus breaking down large masses of material.

The furnace plant of the Dominion Company consists of four furnaces 20 ft. in diameter at the bosh and 85 ft. high. The diameter at the hearth is 11 ft. 9 in., at stock line it is 14 ft. 6 in., and there are 12 6-in. tuyeres. Each furnace is provided with Julian Kennedy's patent top filling apparatus. The furnace shell is 28 ft. in diameter at the mantle and 23 ft. at the top of the furnace. The bustle pipe surrounding the columns is 46 ft. in diameter. The tuyere stacks, 12 in number, are of an improved type, with ball joints and adjustable blow pipes.

Some illustrations of the plants of the Dominion Company are presented herewith.

The Algoma Steel Company.

In addition to the very important plant which has been erected in Nova Scotia by the Dominion Company, another plant of probably hardly less importance is being constructed in Ontario, at Sault Ste. Marie, by a company that has taken the above name from the fact of its being located in the Algoma district. Four blast furnaces are being built, each 90 by 14, two of which will start with charcoal iron, but may be put on to coke by and by, and will have a total annual capacity of 100,000 tons. The other two will start on coke; they are each 90 by 21, and will have a total estimated capacity of 280,000 tons. The total capacity in pig-iron will, therefore, be close on 400,000 tons a year. The ore to be used will be that of the Michipicoten iron ore field, elsewhere referred to.*

* *Vide* p. 46, *ante*.

The Algoma Company are now building a rolling mill and steel plant close to their blast furnaces, which will have an annual capacity of 200,000 tons of ingots and 180,000 tons of finished products Water power will be used for raising steam, and for electric transmission. The

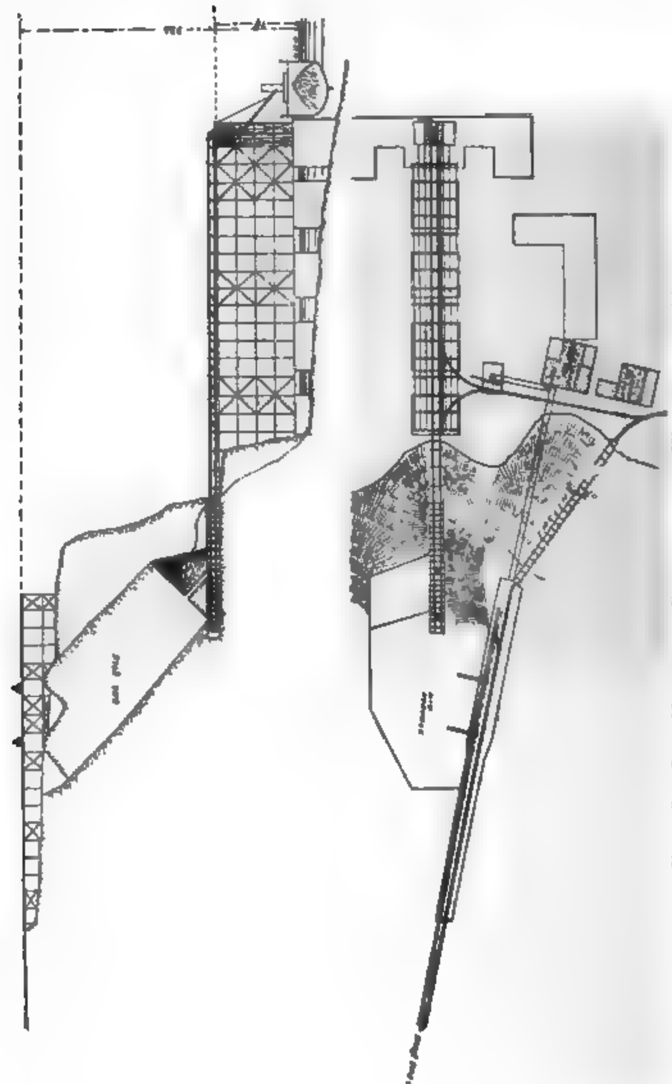


FIG. 78.—ORE HANDLING PLANT AT THE WABANA ORE MINES.

steel plant will embrace two 6-ton Bessemer converters and a 23-in. combined rail and structural steel train. These works are expected to be completed in the spring of 1902.

The Outlook.

It is not improbable that the Dominion Company may for some

years to come be found a very determined and effective competitor in British markets, as, indeed, they have already shown. That they can make pig-iron at a price below any that is known in Britain is extremely probable, and they have the advantage of being on the seaboard, a thousand miles nearer to Europe than United States ports. They have also cheaper, although, probably—as yet, at any rate—less effective labour. But the main fact is that they have a capacity of production which is largely in excess—coupled with that of other new plants—of anything that Canada is likely to consume for years to come, and they have a bounty until July of 1903 of 2 dols. 70 cents (about 11s.) per ton of pig-iron produced, which is continued by decremental stages until it is reduced in 1906-1907 to 60 cents, or 2s. 6d. per ton.

Of the Algoma enterprise I have heard no very favourable opinion, despite some strongly optimistic remarks made by Sir Christopher Furness in the British Press on his return from that region a few months ago. Algoma is more than a thousand miles from suitable fuel, except charcoal—which is plentiful enough—and is nearly as far from any important market. The Algoma Works will also, of course, secure the bounty named, but that is not likely to help them to markets that are likely to be fully occupied by plants much more favourably situated. As for foreign competition being effective with works in such a location, I do not think it is at all likely—not, at any rate, unless and until the Welland Canal has been so far widened and deepened as to allow of water transport down to the St. Lawrence, and thence to Europe without breaking bulk. This is probably the contingency on which the proprietors are counting.

APPENDICES TO GENERAL REPORT.

APPENDIX No. 1.

LETTER FROM THE SECRETARY TO THE PRESIDENT OF THE BRITISH IRON TRADE ASSOCIATION.

165, Strand, London, W.C.
26th February, 1901.

British Trade and Foreign Competition.

Sir,—The extent to which the United States are sending supplies of iron and steel into the United Kingdom is inspiring a good deal of apprehension on the part of home manufacturers. In January our iron and steel exports were 40 per cent. less, and our imports 63 per cent. more, than in the corresponding month of last year. It would be difficult to conceive of a much more alarming situation than this, short of the rapid and inevitable decay of our iron and steel industries. Much has been written on the subject of the competition of the United States. Papers have been read on the subject before the British Iron Trade Association, by Mr. Franklin Hilton, Mr. Jeremiah Head, and Mr. Alfred Baldwin, M.P., and the matter has been incidentally referred to in nearly every annual report of the Association for the last six years. Papers have also been submitted to the Iron and Steel Institute, the West of Scotland Iron and Steel Institute, the Institution of Civil Engineers, and other trade and technical bodies, on the same question, while nearly every paper in the kingdom, from *The Times* downwards, has had special articles on the more prominent phases of foreign competition. We ought, therefore, so far as appearances go, to be well posted on the whole matter. Are these appearances to be relied on, or is it not a fact that the average British manufacturer is still without the knowledge that would enable him exactly to determine what he must do in order to keep in the front, and compete successfully with his rivals?

The success of American competition has been referred to a great variety of causes, some negative and others positive. Here are only a few, taken at random:—

1. The superiority of American ore resources.
2. The greater cheapness of American coke.
3. The cheapness of American transport.
4. The operation of the tariff.
5. The superior skill and industry of American workmen.

6. The greater efficiency of American management.
7. The more economical methods employed in American works.
8. The larger scale on which American industry is carried on.

On the other hand, British iron and steel manufactures are declared to be more or less doomed to continued adversity and decadence for the following among other reasons:—

1. The relatively high cost of fuel and iron ores.
2. The influence of trade unions.
3. The high cost of transport.
4. The influence of shipping rings.
5. The relatively small scale of industrial operations.
6. The relatively ineffective administration.
7. The unfavourable influence of our free trade system.
8. The conservative habits and conditions of our manufacturing classes.
9. The high rate of wages paid, in relation to industrial results.
10. The want of tact and energy on the part of travellers.
11. Insufficient knowledge of foreign languages.
12. Inadequate technical education.
13. The maintenance of obsolete plant.

In view of these reflections on our iron and steel industries, I would venture to suggest whether it may not be worth the while of this Association to appoint a Commission to ascertain what are the real circumstances of the United States in relation to the conditions already named, as well as:—

1. The effect of standard sections and specifications on the cost of production.
2. The extent to which American manufacturers are likely to have surpluses to dispose of.
3. The lowest prices at which such surpluses are likely to be disposed of in Europe.
4. The extent to which the new and the old plants are likely to exceed home needs.
5. The influence of trade unions on American conditions.
6. The standing charges of British and American works, etc.

It is probable that the majority of our great iron and steel making firms have already secured the best information they could, and have arrived at more or less definite conclusions as to their future in relation to foreign competition. Even so, however, it could probably hardly happen that such an inquiry could be instituted as that now suggested without disclosing some, and probably a good deal, of valuable information not already available.

The object of this memorandum is that of directing the minds of the members of the Board to the general question, and not that of formulating specific proposals. If, however, it should be deemed worth further consideration, it may be useful if I proceed to indicate one or two suggestions that may lead to practical proposals.

Probably the most natural order of ideas would be to have one general and several special expert reports, the latter to include (1) raw materials, (2) pig-iron, and (3) steel and steel works plant.

The general report would naturally deal with the economic situation

as a whole in relation to transport, wages, labour conditions, home needs, extent of production, quantities available for exportation, standing charges, organisation, and kindred questions.

Assuming this suggestion to be adopted, there would be four different reports arising out of the inquiry. . . . .

Yours faithfully,

J. STEPHEN JEANS,

Secretary.

SIR JOHN J. JENKINS, *President British Iron Trade Association.*

APPENDIX No. II.

THE COALFIELDS AND THE SEAPORTS OF THE UNITED STATES.

THE following is a summary of an article written in *Mines and Minerals*, for July, 1901, by Mr. Edward W. Parker, of the Geological Survey of the United States:—

"The anthracite and bituminous coalfields of Pennsylvania (in the map Fig. 1 of General Report) are designated by No. 1. No. 2 represents the eastern bituminous steam coal area of Pennsylvania, including the celebrated Clearfield coal, and also that of the counties in the southern part of the State. The coal from this section is shipped *viâ* the Pennsylvania Railroad to New York, Philadelphia, and Baltimore, and by the Baltimore and Ohio to Locust Point, Baltimore. No. 4 designates the Cumberland or Georges Creek coal of Maryland and the Elk Garden and Upper Potomac field of West Virginia. These fields are continuous and practically the same. The seams of this region produce excellent steam coal and one of the best blacksmith coals in the world. It is nearer to tide-water than any of the important bituminous coalfields, and is reached by the Baltimore and Ohio Railroad with terminal at Baltimore (Locust Point Piers), or by Chesapeake and Ohio Canal to Georgetown, D.C. The initial railroad from the Elk Garden portion of the field is the West Virginia Central and Pittsburg, connecting at Cumberland with the Baltimore and Ohio Railroad and the Chesapeake and Ohio Canal. The production of this field is over 5,000,000 short tons annually. The Fairmont region (No. 5), directly west from the Cumberland field, produces about 2,000,000 short tons per year, the product going to tide-water eastward by the Baltimore and Ohio Railroad, or it may be sent to the Ohio River at Parkersburg, and thence by water to New Orleans. Going further south we find the coalfield nearest to tide-water is No. 7. This is the famous steam coal and coke producing region known as the Pocahontas Flat Top. It includes one county, Tazewell, in Virginia, and McDowell and Mercer Counties in West Virginia. In 1880 this region was a wilderness. Development work began in 1881. The production to-day exceeds

4,500,000 tons a year. Its seaboard shipments go by the Norfolk and Western Railroad to Lambert's Point Piers, Norfolk.

"Adjoining the Pocahontas field is the New River region of West Virginia, also famous for its steam coal and coke. The railroad entering this field both east and west is the Chesapeake and Ohio, whose tide-water terminal is Newport News. The New River field includes all the mines in Fayette County. The next county to the west is Kanawha, and from here the larger part of the coal travels west and south instead of east. Some goes by rail, but that which reaches tide-water goes by the Great Kanawha, the Ohio, and the Mississippi Rivers to New Orleans. At the confluence of the Kanawha and the Ohio this coal meets the Pittsburg coal, the product of the Allegheny and Washington Counties in Pennsylvania (No. 3), and the Ohio coals from the celebrated Hocking Valley and Jackson districts (No. 6), in that State. The Kanawha River region in West Virginia (including Putnam County), produces about 1,300,000 tons of coal a year. Allegheny and Washington Counties, Pennsylvania, produced 12,000,000 tons in 1896, while the 'panhandle,' of West Virginia, properly belonging to the district, yields about 300,000 tons more. The two Ohio districts, considered as No. 6, yield 6,000,000 tons or over every year.

"The 'Jellico,' coal region is on the dividing line between south-east Kentucky and north-east Tennessee. It is designated by No. 11, and embraces the Counties of Bell, Knox, and Whitley, in Kentucky, and Anderson, Campbell, and Claiborne Counties in Tennessee. Jellico coal can be sent in nearly a direct line to Norfolk, but its natural outlets are at Charleston, South Carolina, and Brunswick, Georgia, reaching the former by the Southern and the South Carolina and Georgia Railroads, and the former by the Southern Railway direct. A little over 1,500,000 tons is the normal annual production of the Jellico district. No. 12 in the vicinity of Chattanooga, Tennessee, is a small district containing Marion County, Tennessee, and Dade and Walker Counties, Georgia. From this region is obtained what is known as 'Chickamauga' coal, whose reputation as a steam producer is well established. This coal has a direct outlet to Brunswick over the Southern Railroad, or to Tampa, Florida, by connection with the Plant system. The Alabama fields have been included in No. 13. Three counties, Bibb, Jefferson, and Walker, produce over 90 per cent. of the total output of the State, which in 1897 was nearly 6,000,000 tons. Four seaports are easily accessible from this region, Brunswick, Tampa, Mobile, and New Orleans. The last mentioned is reached by three routes, one by rail to Greenville, Mississippi, and thence by Mississippi River, the other two all rail by the Southern, and the New Orleans, and the North-Eastern, or *via* the Western of Alabama, and Lousiville and Nashville, as shown on the map. Finally, we have in the south-west the excellent fuels of Arkansas, and Indian Territory, Nos. 15 and 16, with a combined output of about 2,000,000 tons. The former can reach New Orleans by two routes, one partly by the Mississippi River, the other by the St. Louis, Iron Mountain and Southern, and the Texas and Pacific Railroads, *via* Shreveport. By connection with the International and Great Northern Railroad, the Arkansas coals reach Galveston. The Indian Territory coals also reach Galveston, going by

the Missouri Kansas and Texas Railroad direct, or by connection of this road and the Houston and Texas Central at Sherman, Texas.

"The following statement shows approximately the distance mineral fuels travel in going from the mines to the seaboard :—

"*Region No.* 1.—The chief ports are New York, Philadelphia, and Baltimore. Distances vary from 100 to 200 miles.

"*Region No.* 2.—Chief ports are Philadelphia and Baltimore. Distances about 220 miles.

"*Region No.* 4.—Chief ports, Baltimore and Georgetown, W.C. Distances about 220 miles.

"*Region No.* 5.—Chief port, Baltimore. Distance 300 miles.

"*Region No.* 7.—Chief port, Norfolk. Distance 375 miles.

"*Region No.* 8.—Chief port, Newport News. Distance 420 miles.

"*Region No.* 9.—Chief port, Newport News. Distance 458 miles.

"*Region No.* 11.—Chief ports, Charleston, Brunswick, and Port Tampa. Distances from 500 to 800 miles.

"*Region No.* 12.—Chief ports, Brunswick and Port Tampa. Distances 400 and 670 miles.

"*Region No.* 13.—Chief ports, Brunswick, New Orleans, Mobile, and Galveston. Distances from 240 to 700 miles.

"*Region No.* 16.—Chief port, Galveston. Distances average 540 miles.

"The above are all by railway. The water routes comprise those from ; Pittsburg ; Portsmouth, Ohio ; Kanawha, Dam No. 4 ; and Ashland, Kentucky ; all by the Ohio and Mississippi Rivers to New Orleans, the distance averaging 1,800 miles. Also the two routes from Central Illinois to New Orleans *via* St. Louis and Cairo respectively, partly rail and partly water, the distance averaging 1,300 miles."

APPENDIX No. III.

PENSION FUND OF THE PENNSYLVANIA RAILROAD COMPANY.

AT Philadelphia, Mr. Theo. N. Ely, the chief of motive power of the Pennsylvania Railroad Company, handed me a document descriptive of this recent and important fund, from which the following excerpts are made. The Pennsylvania is the greatest railway corporation in the United States, as will be noted from the details shown in the chapter on transportation.

During the early operation of the present Relief Fund, the pension adjunct was brought in view, provision for that end being made in the departmental regulations, wherein it is expressly stated that such surplus as should arise during specified triennial periods of the operation of the fund is to be set aside as a foundation for the Superannuation and

Pension Fund. The plan then considered involved, however, restrictive action, being confined in its workings to such employés only as were members of the Relief Organisation. The working fund was to be exclusively the Relief Fund surplus. The real labour which eventuated in the development of a feasible plan for the creation of a general Pension Fund was not commenced, however, until the amount available for such purposes grew to proportions that warranted serious consideration of the subject.

A special Committee on Superannuation and Pension Fund was appointed by the Advisory Committee of the Relief Department. The committee examined into and reported upon the various systems of pensioning in operation on upwards of seventy of the leading railways of Europe, America, Asia, Africa, and Australia. It prosecuted investigations along this line with a view to securing data which could be used in constructing a preliminary basis. This necessarily involved the responsible and arduous task of collecting, analysing and collating information for guidance in forming a plan suitable to the requirements of prevailing conditions in the United States. The information obtained from the various sources, however, while edifying and of much interest, did not enable the committee to reach any final conclusion as to the best plan to be adopted, and it became necessary to give the matter original thought, and work it out from that standpoint, rather than upon any basis that existed, the result being an exhaustive preparation of statistical information, embodying results of such a scheme from many different bases, and finally selecting one that would carry with it the assurance of success.

Such a plan was submitted to the president for action of the board, when the whole matter was referred to a special committee of that body. The plan named only embodied the care of superannuated employés. members of the Relief Fund, and the allowances were to be made from that fund. It was subsequently, however, thought advisable and more liberal to make general provision for all old employés by the company assuming the obligation of providing them with a pension allowance in addition to what the Relief Fund could afford to grant to its members who might be retired by the company. Subsequently the characteristics inevitably allied to a question of such magnitude were narrowed down and crystallized into a purely pension basis for all employés, and the result was laid before the directorate's special committee in a revised plan for pensioning employés, whether members of the Relief Fund or not.

The Pension Fund, as practically agreed upon, was established as of January 1st, 1900; the company was to contribute the money necessary for its operation, and to be relieved from any further payments of amounts heretofore made by it on account of what is known as "company relief," *i.e.*, carriage with its own money of Relief Fund members the length of whose sickness exceeds the regulation maximum benefit period of 52 weeks, and who are in consequence entitled to no further Relief Fund benefits on account of such sickness.

A board of officers was created and vested with full power to make and enforce the rules and regulations incident to the care and conduct of the fund, and adopt such means as might be necessary to

determine the eligibility of employés to receive benefits therefrom, and fix the amount of allowance to be paid in each case.

Retirements are voluntary and involuntary; that is, all employés 70 years of age and over are considered as having attained the maximum age limit for active service, and are retired and placed upon the Pension Fund roll, while those whose ages range from 65 to 69 years, and who, in the opinion of the fund administrators, have become physically disqualified, or otherwise permanently incapacitated, after 30 or more years of service, may be either voluntarily or arbitrarily retired and pensioned.

The pension allowance to such retired employés is determined on the following basis:—For each year of service a fixed per centum of the average regular pay for a specific period immediately preceding retirement. It will thus be seen the bases of retirement are age and service, with allowance proportioned to pay received during a designated period preceding retirement.

For such employés, members of the Relief Fund, as may be retired by the company, it is proposed to grant to them from the interest on the Relief Fund surplus an additional allowance on a fixed basis in proportion to the amount they contributed while a member of the Relief Fund, so that each member retired by the company receives this additional allowance because of his membership in the Relief Fund, and it will be paid from the interest on the surplus from the operations of that fund.

In addition to this, the Relief Fund, through its Advisory Committee, has amended the regulations of the Relief Fund in order to make general provision for all its members, so that, in case of sickness or disability, benefits on account thereof will be continued at one-half rates, irrespective of the duration.

The Relief Fund—the expenses of the operation of which, together with any deficiency arising therefrom, are met by the company—affords every employé, physically qualified, and within the proper age limit, an opportunity to make such provision as will insure for himself benefits in case of sickness or disability, during the entire duration thereof, and, in case of retirement by the company, a superannuated allowance in addition to the pension of the company, and to his beneficiaries benefits in case of death.

The object that has been attained, or rather endeavoured to be, is to grant every employé an opportunity to provide for himself, in case of sickness, disability, or death, through the medium of the Relief Fund—which is co-operative and supported jointly by the employés, members thereof, and the company—and when the retirement age is reached the company to reward by granting a pension allowance, in addition to what he will receive from the Relief Fund, to which he has contributed, in the shape of a superannuation allowance on a fixed basis in proportion to the amount he contributed while a member of the Relief Fund.

An important feature is the protection afforded the Pension Fund through the purpose of the company to fix an age limit for admission to the company's service, provision in this respect being that from and after January last, no person shall be employed who is over 35 years

of age, except that former employés desiring reinstatement may be permitted to re-enter the service at the discretion of the board of officers within a certain period; or new employés may be engaged regardless of age limit, if the service for which they are needed requires professional or special qualifications; also that the temporary employment of men, regardless of age limit, shall be permitted for a period not exceeding six months, subject to requisite extension, when engaged upon temporary work.

The necessity for action of this character was requisite, for the reason that the company then had in its service men who, if they desired, could become members of the Relief Fund, and in this manner make preparation for any illness to which they might be subjected in the future or accident that might befall them. In this way every member is afforded an opportunity to make provision for himself during his early service with the company, when it has not yet received from such employé service, both in length and quality, that would entitle him to special consideration at the hands of the company in case of inability to perform his daily labour.

While the Pension Fund is a distinct and separate provision by the company, from its own funds, for the benefit of its employés, and is operated from a distinctive company standpoint, its relation to the relief organisation is unavoidably so intimate as to make it appear as an auxiliary feature thereof. By the addition of the superannuation and pension features to the benefits afforded by the Relief Fund, the company has virtually established for its employés a relief and pension institution.

The new fund affects the entire force of employés on the lines of its system east of Pittsburg and Erie, and scattered along a trackage of over 4,100 miles located in the States of New York, New Jersey, Pennsylvania, Delaware, Maryland and Virginia, and the District of Columbia.

In response to the query as to what are the main objects of the consolidated fund, it was said:—First, the manifestly humane purpose to protect the immediate interests of active, and preserve the future welfare of aged and infirm, employés; and, secondly, to increase and improve the effectiveness of the company's service. The interests of active employés are guarded by a fixed responsibility voluntarily assumed by the company toward the fund, which insures them, during their period of efficient service, fair wages and an adequate allowance in the event of sickness, accident or death; while their future welfare is amply protected by the same assumption of company responsibility, which guarantees them, upon incapacitation by age or infirmities, a fixed life annuity. The company's benefits consist for the most part in the efficiency of service naturally consequent upon the employment of younger and more robust men in the stead of those whose incapacitation has rendered their retirement beneficial to both themselves and the service, also in welding more firmly the mutual interests of employer and employé, thereby the better enabling that concentration of effort and uniformity of action so essential in the management and conduct of corporate affairs.

"No other railway company in the world, whether under State or

private control, possesses a joint fund whose direct and general beneficial features present the admirable system and thoroughness that are so manifest in the one under consideration."

The employés eligible to retirement do not receive the pension allowance as a favour, nor as a charitable act on the part of the company extending it. They are in a position to consider themselves the recipients of a permanent annuity earned by and merited through years of faithful, efficient and loyal service; for it is, above all else, a mark of regard shown by a great corporation, through its administrative representatives, toward each and every employé who has won it by conscientious and capable performance of assigned duties.

APPENDIX No. IIIa.

RULES OF THE PEDRICK & AYER COMPANY IN ENGAGING LABOUR.

FIRST.—We must have full discretion to designate the men we consider competent to perform our work. The number of apprentices, helpers, and handymen to be employed will be determined solely by the company.

SECOND.—While agreeing to recognise local shop committees, composed of representative men among our employés, we will not recognise committees composed of men not in our own employ, nor will we admit of any interference in the management of our business.

THIRD.—We will not arbitrate any question with men on strike.

FOURTH.—No discrimination will be made against any man because of his membership in any organisation.

FIFTH.—We shall be free to employ applicants at wages mutually satisfactory, which shall be established at the time of making the application, always, however, to be governed by local conditions.

SIXTH.—It is the privilege of the employé to leave our employ whenever he sees fit, and it is our privilege to discharge any employé at any time when we see fit.

SEVENTH.—In case of disagreement concerning matters not governed by these Rules and Regulations, we advise our workmen to meet their employer, either individually or collectively, and endeavour to adjust the difficulty on a fair and equitable basis.

EIGHTH.—While the shop will run 58 hours per week at the rate per hour specified in the employé's application, the employer will pay for extra time at the rate of time and a half per hour.

Work on Sundays will be paid for at a rate to be agreed upon at the time.

NINTH.—Each employé pledges himself not to participate in any strike without first submitting any request which he may have to make, and which would form the basis of a strike, to the attention of the management and receiving a reply from them.

The management, on its part, pledges itself to make a reply as soon as the magnitude of the matter and its due consideration will admit.

TENTH.—All men now at work for us must be retained after the

termination of any strike, and no discrimination, in the nature of disagreeable treatment or otherwise, shall be used against them by other employés; and any infringement of this rule will be considered a cause for immediate dismissal.

APPLICATION FOR EMPLOYMENT.

I hereby apply for employment by PEDRICK & AYER COMPANY as a .... at........ ....cents per hour, and I do subscribe to all the foregoing Rules and Regulations.

Philadelphia, Pa.,..................................19

....

Witness:

....

APPENDIX No. IIIb.

AMERICAN STANDARD SPECIFICATIONS AND METHODS OF TESTING IRON AND STEEL.

THE first successful effort in America to standardise specifications for iron and steel, was made in August, 1895, by the Association of American Steel Manufacturers, a technical organisation formed to discuss matters pertaining to the manufacture and use of steel. These specifications were revised by the association on July 17, 1896, and October 23, 1896. They included specifications for structural steel, special open-hearth plate and rivet steel, and structural cast iron.

Although these specifications were criticised and referred to by the technical Press and engineers as "manufacturers'" specifications, they nevertheless grew in favour among engineers and consumers when it was appreciated that just as good steel for the various purposes intended was furnished on these specifications as on engineers' specifications containing numerous other stipulations unnecessary in the present state of the art of making steel. These specifications also accomplished the important work of convincing engineers and customers that more prompt deliveries, and more close competition among manufacturers, was possible on standard specifications containing only such requirements and tests as necessary to ascertain that a satisfactory steel was being furnished, and omitting many useless tests which only serve to add to the expense, or cause delay in manufacturing operations.

The formation of the American Section of the International Association for Testing Materials, on June 16, 1898, gave an excellent opportunity for engineers, consumers, and manufacturers to come together, with a view of framing American standard specifications covering all the various kinds of iron and steel, for among the twenty-two problems which were presented by the parent association, problem No. 1 asked the American Section to co-operate in establishing "international rules and specifications for testing and inspecting iron and steel."

Under authorisation of the Executive Committee of the American Section, the American Branch of Committee No. 1 was increased to 34 members, half of whom were engineers, professors in technical schools, consumers of steel, or delegates from scientific societies, and half representatives from the leading American manufacturers of the various kinds of iron and steel.

This committee held frequent meetings, beginning March 9, 1899. Its sub-committees collected and tabulated the requirements of existing American specifications which were used as a basis in framing the ten proposed American standard specifications, endorsed as representatives of the best American practice, by a letter ballot of the committee, and published in May, 1900. These proposed standards have been discussed by some of the leading American technical societies and journals, as well as by the International Congress on Testing Materials of Construction held in Paris in July, 1900, and by the Iron and Steel Institute in September, 1900.

The American Section of I.A.T.M., at its third annual meeting held in October, 1900, after a detailed discussion, referred the ten proposed standard specifications back to their Committee No. 1. The committee, after frequent meetings, again presented them, with some modifications, at the fourth annual meeting of the American Section, June 29, 1901. They were then adopted, subject to a letter ballot of the full membership of the Section. This letter ballot, canvassed in August, 1901, endorsed the action of the American Section in adopting as American standard the ten revised specifications.

APPENDIX No. IV.

BALDWIN LOCOMOTIVE WORKS.

Apprenticeship Indenture—First Class.

THIS INDENTURE, made by and between George Burnham, William P. Henszey, John H. Converse, William L. Austin, Samuel M. Vauclain, Alba B. Johnson and George Burnham, Jr., trading as BURNHAM, WILLIAMS & COMPANY (hereinafter called "LOCOMOTIVE WORKS"), of the first part, by their respective Attorney in fact.. and .... (hereinafter called "APPRENTICE"), of the second part, WITNESSETH :—

That the said APPRENTICE (with the consent of his..................) doth voluntarily, and of his own free will and accord, put himself apprentice to the said LOCOMOTIVE WORKS, as hereinafter mentioned, he having attained the age of seventeen years, to learn the art, trade and mystery of..and after the manner of an apprentice to serve the said LOCOMOTIVE WORKS at any of their shops or manufactories, from the day of the date hereof, until the time when he will attain the age of twenty-one years, which

attainment of his majority will happen on the................................ day of.................... 19......

It is understood that the partnership of BURNHAM, WILLIAMS & COMPANY, may change by the loss of present, or the addition of new members. It is intended that the firm of BURNHAM, WILLIAMS & COMPANY, however the same shall be constituted or named, so long as it shall conduct the business of THE BALDWIN LOCOMOTIVE WORKS, shall be taken to be the parties with whom this contract is made, and against whom the same can be enforced and as being the parties by whom the same may be enforced.

During all the term of his apprenticeship, APPRENTICE doth covenant and promise and is hereby bound that he will well and faithfully serve his said Masters and obey their lawful commands; that he will do no damage to them, nor wilfully suffer any to be done by others; that he shall not waste the goods of his said Masters, nor lend them unlawfully to any; that he shall not absent himself from their service; that he shall in all things and at all times behave himself as a good and faithful apprentice ought; that he shall comply with the reasonable and proper directions which shall be given to him by his Masters, directly or through their Superintendent of Apprentices, or through any other agent in their employ; that he will faithfully attend at least two evenings in each week during the first three years of his apprenticeship, Free Night Schools, such as during the first year will teach him Elementary Algebra and Geometry, and during the remaining two years shall teach him the rudiments of mechanical drawing; that he shall be subject to be moved or changed from place so place and employment to employment in the shop during each three months; and that he will prove himself fit and competent to receive instruction and to do what shall be reasonably required of him as an apprentice.

It is understood that APPRENTICE has already had a Grammar School education, or sufficient education to render it unnecessary that any provision should be made for his further instruction.

LOCOMOTIVE WORKS do covenant and promise to teach and instruct or cause to be taught or instructed the said APPRENTICE, during such time as he shall remain such, the aforesaid art, trade or mystery by keeping him at work in their manufacturing plant.

It is understood and agreed that if APPRENTICE shall prove incompetent in said art, trade or mystery, or that if at any time he shall be guilty of vicious or immoral conduct, or of repeated absence without leave, or of neglect of duty, or of disobedience of reasonable orders, or if by reason of physical ailments, or long-continued sickness, or for any other good and sufficient reason, LOCOMOTIVE WORKS shall find it advisable to terminate the apprenticeship, that then LOCOMOTIVE WORKS may discharge him from their employ and may terminate and annul this Indenture. In order to avoid the difficulty of proving such conduct, it is agreed that said dismissal for any of the causes aforesaid shall be final and conclusive evidence of the truth thereof. Upon such dismissal the term of apprenticeship shall end.

In lieu of the provision of board, clothing and other expenses and charges of APPRENTICE, LOCOMOTIVE WORKS agree to pay APPRENTICE weekly and every week at the rate following, viz.: ....

cents per hour for the first 310 days actual labour; ....cents per hour for the second 310 days; .... cents per hour for third 310 days, and .... cents per hour for the remainder of said time. Each day's labour of APPRENTICE is to be of ten hours; *Provided*, however, and it is hereby agreed, that at such times as the LOCOMOTIVE WORKS shall consider their business requires the said APPRENTICE to work for more than ten hours the day, then and in such case he shall work such further time as he shall be required by LOCOMOTIVE WORKS, who shall pay him therefor at the same rate per hour as for his usual day's work; and should the number of hours of day's work by the employés, other than apprentices, in the shops of LOCOMOTIVE WORKS be reduced to less than ten, then and in that event the number of hours constituting a day's work to be performed by said APPRENTICE and the compensation may be correspondingly reduced—it being agreed, nevertheless, that the said APPRENTICE shall at all times be subject to the control of his Masters, the reasonable commands of whose agents he shall obey in all matters respecting his conduct while apprentice, and that he shall be subject outside the shops, as well as inside the same, to the supervision of the agents of Masters.

It is further agreed by LOCOMOTIVE WORKS that if said APPRENTICE shall well and faithfully perform his duties as an apprentice, he shall, upon having completed the full term of his apprenticeship, receive the further sum of .... dollars.

In case of an expiration of apprenticeship prior to the full time fixed for its duration, whether such expiration shall result from mutual cancellation of contract, from death, or from other causes unforeseen, not involving a discharge of APPRENTICE for cause, there shall be paid to him or for his benefit at such earlier termination of the apprenticeship such proportion of said above named final sum as the time of service elapsed shall bear to the total time contemplated.

In case of the termination of the apprenticeship by reason of the discharge of APPRENTICE for any of the causes above specified, no portion of said final sum shall be payable to him or for his benefit.

In Witness Whereof, the said parties have hereunto set their hands and seals; and the said... in token of .... consent, has signed as a witness hereto, this .... day of.............................. 19......

Witnesses:

GEORGE BURNHAM. [SEAL.]
WILLIAM P. HENSZEY. [SEAL.]
JOHN H. CONVERSE. [SEAL.]
WILLIAM L. AUSTIN. [SEAL.]
SAMUEL M. VAUCLAIN. [SEAL.]
ALBA B. JOHNSON. [SEAL.]
GEORGE BURNHAM, JR. [SEAL.]
By their Attorney in fact.

[SEAL.]
[SEAL.]

I sign by way of expressing my consent.

....

Parent or Guardian.

APPENDIX No. V.

BALDWIN LOCOMOTIVE WORKS.

Apprenticeship System—Circular No. 1.

In view of the fact that in recent years manufacturing has tended so largely toward specialisation that young men apprenticed to mechanical trades have been able in most cases only to learn single processes, and, as a result, the general mechanic has threatened to become practically extinct, to the detriment of manufacturing interests generally, the Baldwin Locomotive Works have established a system of apprenticeship on a basis adapted to existing social and business conditions.

Apprentices are taken in three classes, as follows —

Apprentices of the First Class.

The first class will include boys seventeen years of age, who have had a good common school education, and who bind themselves by indentures (with the consent of a parent or guardian in each case) to serve for four years; to be regular at their work; to obey all orders given them by the foreman or others in authority; to recognise the supervision of the firm over their conduct out of the shop as well as in it; and to attend such night schools during the first three years of their apprenticeship as will teach them, in the first year, elementary algebra and geometry; and in the remaining two years, the rudiments of mechanical drawing.

Apprentices of the Second Class.

The second class indenture is similar to that of the first class, except that the apprentice must have had an advanced grammar school training, including the mathematical courses usual in such schools. He must bind himself to serve for three years, and to attend night schools for the study of mechanical drawing at least two years, unless he has already sufficiently acquired the art.

Apprentices of the Third Class.

The third class indenture is in the form of an agreement made with persons twenty-one years of age or over, who are graduates of colleges, technical schools, or scientific institutions, and who desire to secure instruction in practical shop work.

The indentures or agreement in each case place upon the firm the obligation to teach the apprentice his art thoroughly and to furnish him abundant opportunity to acquire a practical knowledge of mechanical business. The firm is also bound to retain the apprentice

in service until he has completed the term provided for in the indenture or agreement, provided his services and conduct are satisfactory. In all cases the firm reserves the right to dismiss the apprentice for cause.

The rates of pay in the different classes are as follows:—

	1st year per hr.	2nd year per hr.	3rd year per hr.	4th year per hr.
Apprentices of the First Class ...	5c.	7c.	9c.	11c.
Apprentices of the Second Class ...	7c.	9c.	11c.	
Apprentices of the Third Class ...	13c.	16c.		

In addition to the rates mentioned above, apprentices of the first class each receive an additional sum of 125 dols., and apprentices of the second class an additional sum of 100 dols. at the expiration of their full term of apprenticeship respectively.

By the course of training provided for in this system it is believed that a great benefit will accrue to the mechanic as well as to the employer. To young men who have received a thorough technical education, the two years' course in shop work is especially recommended.

APPENDIX No. VI.

BALDWIN LOCOMOTIVE WORKS.

Apprentice's Application.

....190

BURNHAM, WILLIAMS & CO.

Gentlemen:—I desire to become an apprentice in your employ, to learn the trade of ....

I was......................years of age at my last birthday, which occurred on the ....day of ....19.........

am sound in body, industrious and intelligent, having attended ....school, and have a knowledge of the following studies, viz.:—

....

....

If my application is considered favourably, I am willing to be indentured for the necessary term of years.

Respectfully yours,

....

....

APPENDIX No. VII.

INDENTURE FOR APPRENTICESHIP AT THE WORKS OF W. SELLERS & CO.

NOTE:—Applications for Indenture as First Class Apprentices will be considered from boys who have had a good common school education, and are not over seventeen years and three months of age. The compensation for this class is five (5) cents per hour first year, seven (7) cents per hour second year, nine (9) cents per hour third year, and eleven (11) cents per hour fourth year, with the further sum of 125 dols. at expiration of term of apprenticeship.

Applications for Indenture as Second Class Apprentices will be considered from boys who have had an advanced Grammar or High School training, and are not over eighteen years of age. The compensation for this class is seven (7) cents per hour first year, nine (9) cents per hour second year, and eleven (11) cents per hour third year, with the further sum of 100 dols. at expiration of term of apprenticeship.

Applications for a special course of instruction, covering a period of two years, will be considered from young men over twenty-one years of age who are graduates of colleges, technical schools or scientific institutes.

THIS INDENTURE, made by and between WILLIAM SELLERS & CO., INCORPORATED, of the City of Philadelphia, Engineers, of the first PART,—and .... of the second PART, Witnesseth that the said ....(with the consent of his ....

doth voluntarily, and of his own free will and accord, put himself apprentice to the said WILLIAM SELLERS & CO., INCORPORATED, to learn the art, trade and mystery of................................. and after the manner of an apprentice to serve the said WILLIAM SELLERS & CO., INCORPORATED, from the day of the date hereof, until the................. day of the..............month, in the year of our Lord, one thousand nine hundred and....................... at which time the said.............. .... will have attained the age of twenty-one years. During all which time the said... ....doth covenant and promise, and is hereby bound, that he will well and faithfully serve his masters and obey their lawful commands; that he will do no damage to the Company, nor wilfully suffer any to be done by others. He shall not waste the goods of the Company, nor lend them unlawfully to any. He shall not absent himself from its service, but in all things and at all times he shall carry and behave himself as a good and faithful apprentice ought, during the whole time aforesaid. AND the said WILLIAM SELLERS & CO., INCORPORATED, on its part, covenants and promises to use proper effort to teach and instruct, or cause to be taught and instructed, the said ....during such time as he shall remain the apprentice of the Company, in the art, trade or mystery of .... and that in consideration of the services, and in lieu of the board, clothing, and other expenses or charges of him the said..the said WILLIAM SELLERS

& Co., INCORPORATED, shall to pay him as follows, viz., for every quarter hour during which the said..shall work for the Company at the rate of.........cents per quarter hour, until he shall have worked for it the time or period of 3,100 hours; and after that at the rate of.........cents per quarter hour, until he shall have worked for it the further time or period of 3,100 hours; and after that at the rate of.........cents per quarter hour until he shall have worked for it the further time or period of 3,100 hours; and for all the remainder of the time during which he shall work for it, at the rate of.........cents per quarter hour; said payments to be paid semi-monthly, or on the regular days of the Company for the payment of wages; during the continuance of this agreement each day's labour of him the said.. .... to be of ten hours; Provided, however, and it is hereby agreed, that at such times as the said WILLIAM SELLERS & Co., INCORPORATED, shall consider that its business requires the said.. to work for more or less than ten hours in the day, then and in such case he shall work such time as he shall be required by the said WILLIAM SELLERS & Co., INCORPORATED, who shall pay him therefor at the same rate per quarter hour as for his usual day's work—it being agreed nevertheless that the said..shall at all times be subject to the control of his masters, whose reasonable commands he shall obey in all matters respecting his conduct while an apprentice.

It is however expressly understood and agreed, by and between the said WILLIAM SELLERS & Co., INCORPORATED, and the said........... ....that if he shall at any time be guilty of vicious or immoral conduct, or of repeated absences without leave, or of neglect of duty, or of disobedience of reasonable orders that then the said WILLIAM SELLERS & Co., INCORPORATED, may discharge the said................. ....from its employ, and terminate and annul this Indenture; and the said dismissal for any of the causes aforesaid shall be final and conclusive evidence of the truth thereof.

For the faithful performance of the duties of the said................ ....as said apprentice, during the full term of this Indenture, the said WILLIAM SELLERS & Co., INCORPORATED, upon its completion and his attaining the full age of twenty-one years, will pay to him the said...the additional sum of five-tenths of one cent for each quarter hour worked by him under this Indenture.

IN WITNESS whereof, the said party of the first part has hereunto affixed its corporate seal and the other parties hereto have hereunto affixed their hands and seals, this.......... ....day of............................A.D. 19.....to take effect on the ....day of........................ .............A.D. 19..... as though it had been executed on that day.

I,..of the first part being ....years of age the...............................day of....................................19......and having determined to learn the art, trade, or mystery of..under the instruction of WILLIAM SELLERS & Co., INCORPORATED, of the

second part, providing it will accept me as an apprentice; to all of which my...is consenting. I now agree and am hereby bound to serve WILLIAM SELLERS & CO., INCORPORATED, of Philadelphia, for the space of Six Months, from and after....................................19.....and with its consent to make myself an apprentice to the trade aforesaid, upon the terms and conditions as expressed in the blank form of Indenture herewith, the said WILLIAM SELLERS & CO., INCORPORATED, hereby agree to pay me at the rate of nine-tenths of a cent per quarter hour during such time as I may remain in its employ for the purpose aforesaid; it being expressly understood and agreed, that the said WILLIAM SELLERS & CO., INCORPORATED, may at any time accept my services as an apprentice under the Indenture herewith, or discharge me from its employ.

In Witness Whereof, the said party of the first part has hereunto affixed his hand and seal. And the said.................................... ....in token of his consent, hereunto has set his hand and seal, and the party of the second part has hereunto affixed its corporate seal this............................day of.......................19.....

....*Prest.*

Attest........................... ....*Secy.*

APPENDIX No. VIII.

AGREEMENT AS TO INVENTIONS AND DISCOVERIES ADOPTED BY W. SELLERS & CO.

THIS AGREEMENT made this.....................................day of...19........Between WILLIAM SELLERS & CO., INCORPORATED (hereinafter called Company), of the first part and.. (hereinafter called employé) of the second part, witnesseth:

Whereas, employé is employed by WILLIAM SELLERS & CO., INCORPORATED, of Philadelphia, Pennsylvania, on the condition that the said Company shall have the benefit of all of his time and all of his talents, in good faith, in all matters connected with its operations while in its employ;

Now, therefore, for and in consideration of one dollar, the receipt of which is hereby acknowledged, and of mutual agreements, said employé hereby agrees that he will assign absolutely to said Company all inventions or discoveries of any kind which he may invent or conceive of while in the employ of said Company, at any time either during the present, or during any extended term, in all matters connected with its operations or in or about such plant, tools, apparatus

and machinery, and the processes for manufacturing the same, as in the usual course of the business of the said Company it may have heretofore constructed or is likely to construct hereafter.

And the said employé further agrees that he will, when requested by the Manager of the said Company, execute all lawful papers that may be required to obtain Letters Patent for any inventions he may make, as aforesaid, either in this or in any foreign country, or for the reissue or the extension thereof, and will make, execute, and deliver to the said Company due assignments, in writing, of all the interest that he may or might have in and to all such inventions or improvements and in and to all such Letters Patent as may be granted pursuant thereto.

And the said employé further agrees that he will not make any application for a patent in the United States or in any foreign country without first submitting the specifications and drawings for the same to the President of the said Company, and receiving from him a statement, in writing, that the subject-matter does not pertain to the business of the said Company.

And the said employé further agrees that any patent or any interest therein that may be granted or assigned to him in contravention of this agreement shall be and become the property of the Company, and, upon demand, in writing, by the President of the Company, shall be duly assigned to it.

It is understood and agreed that all expenses in connection with any application for a patent, in this or in any foreign country, which may be assigned to or which may otherwise become the property of WILLIAM SELLERS & CO., INCORPORATED, under this agreement, shall be borne by WILLIAM SELLERS & CO., INCORPORATED.

Said Company, in consideration of the foregoing, agrees to employ employé for the term of...
for a compensation by it to be paid of...
....and
thereafter from term to term at a like compensation, or at such other compensation as may be mutually agreed upon, until such time as employé or Company shall, at the option of either, see fit to dissolve the connection.

In Witness Whereof, the said employé has hereunto set his hand and seal and the Company has caused to be affixed its corporate seal the day and year first above written.

Witnesses:

....

....

Attest:

....

Treasurer. *President.*

APPENDIX No. IX.

FORMS FOR SHOP ORDERS AT WORKS OF W. SELLERS & CO.

Shop Order for Week.

..............................190 No. of Order....................

Order Book Folio.............. Charge..................................

For..........................

Delivered......................................190 ....

Sig...Receiving and Delivering Clerk.

WEIGHTS.

Boxing Lumber feet, Hauling loads to Expense

Charged...............................190

Sales Book Folio.................Sales Clerk Sig,.............................

Store Clerk Sig.............................. WM. SELLERS & Co., INCORPORATED.

Per......................................

Cost Book Folio..............Cost Clerk Sig...

() Received by Foreman.........................

() Finished 190 Gang Foreman
....

() Received by Receiving and Shipping Clerk.
....

() " " Sales "
....

() " " Order "
....

() " " Cost "
....

Inspected 190...................... Clerk.

Order No.......................

[illegible] ......190 Finished.................190

Finished Weight......................

Wages.	Total wages.	Expenses.	Material.	Total cost.
[illegible] SB SB F Mills D;				

[illegible] letters signifying the different shops or departments.

APPENDIX No. X.

PIECE WORK FORM ADOPTED AT MIDVALE STEEL WORKS.

Fill up and Return on Completion of this Work.

STATEMENT OF TIME SPENT ON PIECE WORK RATE ....

The work on this rate was finished ....

Workman's Name	Date.	Total Amount of Work	Total Time.	Total Wages.	Rate per Hour.
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

Remarks...

....

....

Signed..................................

APPENDIX No. XI.

MIDVALE BENEFICIAL ASSOCIATION.

Agreement for Power of Attorney.

THIS AGREEMENT, Made the ....day of

.......................190......, between Midvale Beneficial

Association, of the first part, and...

....of the second part,

[illegible] The said party of the second part has become [illegible] the said Association and has assumed certain liabilities, [illegible] desirous to secure; the parties hereto agree as [illegible] to render such security effectual, in consideration [illegible] of the second part being admitted into said [illegible] upon his promise to enter into this agreement.

[illegible] the second part, will deliver to such person as [illegible] the Treasurer of the Midvale Steel Company, [illegible] collect from time to time, and to receipt for, [illegible] shall be necessary to pay all sums which [illegible] in consequence of his said membership. [illegible] the nature of an assignment of his wages, [illegible] irrevocable.

[illegible] seal of the said party of the second part [illegible]

....

[SEAL.]

APPENDIX No. XII.

EXTRACT FROM WAGES BOOK AT WORKS OF WM. SELLERS & COMPANY, GIVING ACTUAL WAGES, OCT., 1901.

Pay Roll of Employés in ....

Name.	Register No.	Work.	For Week ending........................ Quarter Hours.	Rate. Dols.	D. W. Wages. Dols.		P. W. Wages. Dols.		Amount Due. Dols.	
Mechanics.										
Ruth, Harry	1171	Fitter	204	5·8			13	57	13	57
Campbell, A.	1172	„	219	6·7			14	67	14	67
Klenk, Jno	1173	„	24 201	5·0	10	05	3	60	13	65
Mungesser, H.	1174	Elec.	225	5·5	12	37			12	37
Knight, Amos	1175	Fitter	225	8·2	18	37			18	37
Acuff, Alfred	1176	„	224	5·5			18	84	18	84
Brown, Edw.	1177	„	225	5·5			12	39	12	39
Culbeertson, Jas.	1178	Carp.	223	5·5	12	26			12	26
Lathe Hands.										
Buchanan, Wm.	1329	La.	191 24	6·3	1	51	17	36	18	87
Kimes, Jos.	1330	„	225	7·5			33	50	33	50
Stulz, J. Louis	1331	Tool Grind	217	3·0			12	75	12	75
Kniveton, Jno. W. ...	1332	Appr.	186 133	2·0		66	7	21	7	87
Rutter, C. W.	1333	Dr.	144 81	5·5	4	45	8	78	13	23
Garlick, Harry	1334	T. La	225	3·0			15	42	15	42
Richards, Frank	1335	„	223	3·0			10	63	10	63
Labourers.										
McLaughlin, Wm. ...	1567	Help	241	3·0	7	23			7	23
Meier, Chas.	1568	„	249	3·0	7	47			7	47
Ryder, Chas.	1569	„	225	3·5	7	87			7	87
Fagan, B. B.	1570	Clerk	225	2·5	5	62			5	62
Prindle, N. B.	1571	Help	225	3·8	8	55			8	55
Glunz, Jno.	1572	„	225	2·5	5	62			5	62
Haggerty, Wm.	1573	„	61	3·0	1	83			1	83
Raff, Harry	1574	„	223	3·0	6	69			6	69

APPENDIX No. XIII.

AMERICAN RAILWAY RATES FOR THE TRANSPORT OF MINERAL AND IRON AND STEEL TRAFFIC, SPECIALLY COMPILED FOR THIS REPORT BY THE INTER-STATE COMMERCE COMMISSION.

Bituminous Coal Rates.

INTER-STATE COMMERCE COMMISSION,
AUDITOR'S OFFICE, NOVEMBER 2, 1901.

STATEMENT SHOWING THE MILEAGE, RATE PER TON OF 2,000 LBS., AND RATE PER TON PER MILE ON BITUMINOUS COAL FROM POINTS IN VIRGINIA AND W. VIRGINIA TO NORFOLK, VA.

From	To Norfolk, Va.		
	Mileage.	Rate in cents per ton of 2,000 lbs.	Rates per ton per mile.
Pocahontas, Va. ...	373	170	0·46
Roderfield, W. Va. ...	413	170	0·41
Norton, Va.	466	180	0·39
Thacker, W. Va. ...	456	185	0·41
Radnor, W. Va. ...	530	190	0·36

No special rates on export traffic.

From	To Norfolk, Va.		
	Mileage.	Rate in cents per ton of 2,000 lbs.	Rate per ton per mile.
Coalburg, W. Va. ..	448	210	0·47
Gauley, W. Va.	426	210	0·49
Hawk's Nest W. Va, ...	419	195	0·47
Thurmond, W. Va. ..	401	195	0·49

No special rates on export traffic.

Bituminous Coal Rates (*continued*).

INTER-STATE COMMERCE COMMISSION,
AUDITOR'S OFFICE, NOVEMBER 2, 1901.

TATEMENT SHOWING DISTANCE, RATE IN CENTS PER TON OF 2,240 LBS. AND IN CENTS PER TON OF 2,000 LBS. PER MILE ON BITUMINOUS COAL FROM MINES IN PENNSYLVANIA, MARYLAND AND WEST VIRGINIA TO NEW YORK, N.Y., PHILADELPHIA, PA., AND BALTIMORE, MD.

From	To New York, N.Y.			To Philadelphia, Pa.			To Baltimore, Md.		
	Mileage.	Rate per ton of 2,240 lbs.	Rate per ton of 2,000 lbs. per mile.	Mileage.	Rate per ton of 2,240 lbs.	Rate per ton of 2,000 lbs. per mile.	Mileage.	Rate per ton of 2,240 lbs.	Rate per ton of 2,000 lbs. per mile.
Mines in Penna:									
Clearfield, Pa. ...	346	180	0·47				250	145	0·52
State Line, Pa. ...	379	195	0·46		(No	Rates)	283	145	0·46
Latrobe, Pa.	395	180	0·41				299	145	0·43
Mines in Maryland:	(To	Jerse	y City)						
Cumberland, Md. ...	377	185	·0047	287	145	0·45	192	145	0·675
					*110	0·34		*103	0·48
Piedmont, Md. ...	405	185	0·41	315	145	0·41	220	145	0·59
					*110	0·31		*103	0·42
Deek Park, Md. ...	425	185	0·39	355	145	0·36	240	145	0·54
					*110	0·29		*103	0·38
Mines in W. Virginia:	(To	Jerse	y City)						
Clarksburg, W. Va. ...	501	195	0·35	411	170	0·37	316	170	0·48
					*135	0·24		*128	0·36
Fairmont, W. Va. ...	501	195	0·35	411	170	0·37	316	170	0·48
					*135	0·24		*128	0·36
Moundsville, W. Va....	567	195	0·31	477	170	0·32	382	170	0·4
					*135	0·21		*128	0·3
Mines in Penna:	(To	Jerse	y City)						
Connellsville, Pa. ...	469	195	0·37	380	170	0·4	284	170	0·53
					*135	0·27		*128	0·4
Meyersdale, Pa. ...	414	170	0·36	324	145	0·4	229	145	0·57
					*110	0·3		*103	0·4

(Rates marked thus * for outside of Capes).

No special rates on export traffic to New York.

Bituminous Coal Rates (*continued*).

STATEMENT SHOWING DISTANCE, RATE AND RATE PER TON PER MILE ON BITUMINOUS COAL FROM COALBURG, W. VA., GAULEY, W. VA., HAWKSVILLE, W. VA., AND THURMOND, W. VA., TO NEWPORT NEWS, VA.

Bituminous Coal. From.	To Newport News, Va. Mileage.	Rate.	Rate per ton of 2,000 lbs. per mile.
Coalburg, W.Va.	428	185 In cents per Ton of 2,000 lbs.	0·43
		*180 " " " 2,240 "	0 38
		†135 " " " 2,240 "	0·28
Gauley "	406	185 In cents per Ton of 2,000 lbs.	0·46
		*180 " " " 2,240 "	0·4
		†135 " " " 2,240 "	0·29
Hawksville "	399	170 In cents per Ton of 2,000 lbs.	0·43
		*170 " " " 2,240 "	0·38
		†125 " " " 2,240 "	0·28
Thurmond "	381	170 In cents per Ton of 2,000 lbs.	0·45
		*170 " " " 2,240 "	0·4
		†125 " " " 2,240 "	0·3

Note.—Rates marked thus * are for bunkerage purposes only.
Rates marked thus † when destined beyond the Capes.

STATEMENT SHOWING THE DISTANCE, RATE PER TON OF 2,000 LBS., AND RATE PER TON PER MILE, ON BITUMINOUS COAL FROM PITTSBURG, PA., TO CHICAGO, ILL., EAST ST. LOUIS, ILL., CINCINNATI, O., LOUISVILLE, KY, AND BUFFALO, N.Y.

To	From Pittsburg, Pa. Mileage.	Rate in cents per ton of 2,000 lbs.	Rate per ton per mile.
Chicago, Ill	468	175	0·37
East St. Louis, Ill.	611	215	0·35
Cincinnati, Ohio	313	135	0·43
Louisville, Ky.	423	175	0·41
Buffalo, N.Y.	235	100	0·43

Iron and Steel Rates.

STATEMENT SHOWING THE DISTANCE, RATE, AND RATE PER TON PER MILE ON IRON AND STEEL COMMODITIES, SHOWN BELOW, FROM PITTSBURG, PA., TO NEW ORLEANS, LA., PENSACOLA, FLA., AND MOBILE, ALA.

	From Pittsburg, Pa.					
Miles.	1,142.		1,076.		1,c93.	
To	New Orleans, La.		Pensacola, Fla.		Mobile, Ala.	
Commodities.	Rate in cents per 100 lbs., except on Steel Rails, which is per ton of 2,240 lbs.	Rate per ton of 2,000 lbs. per mile.	Rate in cents per 100 lbs., except on Steel Rails, which is per ton of 2,240 lbs.	Rate per ton of 2,000 lbs. per mile.	Rate in cents per 100 lbs., except on Steel Rails, which is per ton of 2,240 lbs.	Rate per ton of 2,000 lbs. per mile.
Steel Rails... ...	444	0·35	444	0·37	444	0·36
Merchant Iron ...	29	0 5	29	0·54	20	0·53
Structural Iron ...	29	0·5	29	0·54	29	0·53
Tinplate	29	0·5	29	0·54	29	0·53

No special rates on export traffic.

Iron and Steel Rates (*continued*).

INTER-STATE COMMERCE COMMISSION,
AUDITOR'S OFFICE, NOVEMBER 2, 1901.

STATEMENT SHOWING THE DISTANCE, RATE, AND RATE PER TON PER MILE ON IRON AND STEEL SHOWN BELOW, FROM PITTSBURG, PA., TO EAST ST. LOUIS, ILL., AND CHICAGO, ILL.

Commodities.	From Pittsburg, Pa.			
	Mileage. 621.		Mileage. 468	
	To East St. Louis, Ill.		To Chicago, Ill.	
	Rate per Ton per Mile (of 2,000 lbs.).	Rate.	Rate per Ton per Mile (of 2,000 lbs.).	Rate.
Pig-iron ...	0·445	310 per ton 2,240 lbs.	0·477	250 per ton 2,240 lbs.
Steel Rails ..	0·467	325 „ „ „	0·535	280 „ „ „
„ Blooms ...	0·474	330 „ „ „	0·515	270 „ „ „
„ Billets ...	0·474	330 „ „ „	0·515	270 „ „ „
„ Bars ...	0·474	330 „ „ „	0·515	270 „ „ „
„ Sheets ...	0·531	16½ per 100 lbs.	0·705	16½ per 100 lbs.
Wire Rods ...	0·474	330 per ton 2,240 lbs.	0·515	270 per ton 2,240 lbs.
Merchant Iron ...	0·531	16½ per 100 lbs.	0·641	15 per 100 lbs.
Tinplate ...	0·628	19½ „ „	0·769	18 „ „
Structural Iron ...	0·531	16½ „ „	0·641	15 „ „

Iron and Steel Rates (*continued*).

STATEMENT SHOWING DISTANCE, RATE, AND RATE PER TON PER MILE ON IRON AND STEEL, SHOWN BELOW FROM BIRMINGHAM, ALA., TO NEW ORLEANS, LA., MOBILE, ALA., PENSACOLA, FLA., SAVANNAH, GA., AND CHARLESTON, S.C.

Commodities.	From Birmingham, Ala.									
	Mileage. 349.		Mileage. 276.		Mileage. 259.		Mileage. 447.		Mileage. 446.	
	To New Orleans, La.		To Mobile, Ala.		To Pensacola, Fla.		To Savannah, Ga.		To Charleston, S.C.	
	Rate per ton of 2.000 lbs. per mile.	Rate. See Notes.	Rate per ton of 2,000 lbs. per mile.	Rate. See Notes.	Rate per ton of 2,000 lbs. per mile.	Rate. See Note.	Rate per ton of 2,000 lbs. per mile.	Rate. See Notes.	Rate per ton of 2,000 lbs. per mile.	Rate. See Notes.
Pig-iron ...	0·354	140 note 1	0·316	100 note 1	0·341	100 note 1	0·345	175 note 1	0·346	175 note 1
Steel Rails ...	0·74	13 „ 3	0·94	13 „ 3	1·0	13 „ 3	0·62	14 „ 3	0·63	14 „ 3
„ Blooms ...	0·71	250 „ 2	0·9	250 „ 2	0·97	250 „ 2	0·39	175 „ 4	0·39	175 „ 4
„ Billets ...	0·71	250 „ 2	0·9	250 „ 2	0·97	250 „ 2	0·39	175 „ 2	0·39	175 „ 2
„ Bars ...	0·71	250 „ 2	0·9	250 „ 2	0·97	250 „ 2	0·39	175 „ 2	0·39	175 „ 2
„ Sheet ...	0·74	13 „ 3	0·94	13 „ 3	1·0	13 „ 3	0·62	14 „ 3	0·63	14 „ 3
Wire Rods ...	0·63	11 „ 3	0·8	11 „ 3	0·85	11 „ 3	0·62	14 „ 3	0·63	14 „ 3
Merchant Iron ...	0·74	13 „ 3	0·94	13 „ 3	1·0	13 „ 3	0·62	14 „ 3	0·63	14 „ 3
Tinplate ...	0·8	14 „ 3	1·0	14 „ 3	1·08	14 „ 3	1·43	32 „ 3	1·43	32 „ 3
Structural Iron ...	0·74	13 „ 3	0·94	13 „ 3	1·0	13 „ 3	0·62	14 „ 3	0·63	14 „ 3
Coal ...	0·36	125 „ 2	0·4	110 „ 2	0·42	110 „ 2	0·4	180 „ 2	0·4	180 „ 2

Note 1.—Per Ton of 2,268 lbs. Note 2.—Per Ton of 2,000 lbs. Note 3.—In cents per 100 lbs. Note 4.—In cents per ton 2,240 lbs.
No special rates on export traffic.

Iron and Steel Rates (*continued*).

STATEMENT SHOWING THE DISTANCE, RATE, AND RATE PER TON, OF 2,000 LBS. PER MILE ON IRON AND STEEL FROM PITTSBURG, PA., TO NEW YORK, N.Y., PHILADELPHIA, PA., BALTIMORE, MD., NORFOLK, VA.

	From Pittsburg, Pa.			
	444 miles.		353 miles.	
	To New York, N.Y.		To Philadelphia, Pa.	
	Rate.	Rate per Ton per Mile.	Rate.	Rate per Ton per Mile.
Pig-iron	220 (ton 2,268 lbs.)	0·44	200 (ton 2,268 lbs.)	0·5
Steel Rails	280 „ 2,240 „	0·56	240 „ 2,240 „	0·6
„ Blooms ...	240 „ „ „	0·46	220 „ „ „	0·56
„ Billets	240 „ „ „	0·46	220 „ „ „	0·56
„ Bars	240 „ „ „	0·46	220 „ „ „	0·56
„ Sheet	13 (per 100 lbs.)	0·59	12 (per 100 lbs.)	0·68
Wire Rods	240 (ton 2,240 lbs.)	0·46	220 (ton 2,240 lbs.)	0·56
Merchant Iron ...	13 (per 100 lbs.)	0·59	12 (per 100 lbs.)	0·68
Tinplate	18 „ „ „	0·81	16 „ „ „	0·91
Structural Iron ...	13 „ „ „	0·59	12 „ „ „	0·68

	From Pittsburg, Pa.			
	334 miles.		503 miles.	
	To Baltimore, Md.		To Norfolk, Va.	
	Rate.	Rate per Ton per Mile.	Rate.	Rate per Ton per Mile.
Pig-iron	190 (ton 2,268 lbs.)	0·5	240 (ton 2,268 lbs.)	0·42
Steel Rails	230 „ 2,240 „	0·65	280 „ 2,240 „	0·5
„ Blooms ...	210 „ „ „	0·56	260 „ „ „	0·46
„ Billets	210 „ „ „	0·56	260 „ „ „	0·46
„ Bars	210 „ „ „	0·56	260 „ „ „	0·46
„ Sheet	11½ (per 100 lbs.)	0·7	16 (per 100 lbs.)	0·64
Wire Rods	210 (ton 2,240 lbs.)	0·56	260 (ton 2,240 lbs.)	0·46
Merchant Iron ...	11½ (per 100 lbs.)	0·7	16 (per 100 lbs.)	0·64
Tinplate	15 „ „ „	0·89	20 „ „ „	0·8
Structural Iron ...	11½ „ „ „	0·7	16 „ „ „	0·64

No special rates on export traffic.

Iron and Steel Rates (*continued*).

STATEMENT SHOWING THE DISTANCE, RATE IN CENTS PER 100 LBS., AND RATE PER TON PER MILE ON IRON AND STEEL, SHOWN BELOW, FROM CHICAGO, ILL., ST. LOUIS, MO., AND KANSAS CITY, MO., TO DENVER, COLO., SALT LAKE CITY, UTAH, AND SAN FRANCISCO, CAL.

	To Denver, Colo.						To Salt Lake City, Utah.						To San Francisco, Cal.					
Mileage.	1,025		916		639		1,589		1,480		1,203		2,354		2,277		2,064	
From	Chicago, Ill.		St. Louis, Mo.		Kansas City, Mo.		Chicago, Ill.		St. Louis, Mo.		Kansas City, Mo.		Chicago, Ill.		St. Louis, Mo.		Kansas City, Mo.	
Commodities.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.	Rate in cents per 100 lbs.	Rate per ton per mile.
Pig-iron ...	41	0·8	36	0·78	25	0·78	75	0·93	70	0·95	59	0·98	50	0·424	50	0·48	50	0·44
Steel rails ...	43	0·84	38	0·83	25	0·78	145	1·8	140	1·9	118	1·96	60	0·51	60	0·58	60	0·53
„ blooms	53½	1·0	48	1·0	35	1·1	89	1·1	84	1·1	70½	1·17	50	0·424	50	0·48	50	0·44
„ billets	53½	1·0	48½	1·0	35	1·1	89	1·1	84	1·1	70½	1·17	50	0·424	50	0·48	50	0·44
„ bars ...	77	1·5	72	1·6	50	1·6	145	1·2	140	1·9	118	1·96	50	0·424	50	0·48	50	0·44
„ sheets	77	1·5	72	1·6	50	1·6	145	1·2	140	1·9	118	1·96	80	0·68	80	0·77	80	0·70
Wire Rods	77	1·5	72	1·6	50	1·6	145	1·2	140	1·9	118	1·96	75	0·64	65	0·63	70	0·61
Merchant iron	77	1·5	72	1·6	50	1·6	110	1·4	105	1·4	83	1·38	75	0·64	65	0·63	70	0·61
Tinplate ...	69	1·3	64	1.	42	1·3	75	0·93	70	0·95	70	1·16	50	0·424	50	0·48	50	0·44
Structural iron	77	1·5	72	1.	50	1·6	80	1·0	72½	0·98	72½	1·2	75	0·64	75	0·72	75	0·66

APPENDIX No. XIV.

CHIEF RULES OF THE MIDVALE BENEFICIAL ASSOCIATION.

Officers.

A Board of seven (7) Trustees shall be annually appointed by the Superintendent of the Midvale Steel Company, in the first week in January, from among the members of the Association, to serve during the ensuing year, or until their successors are appointed. Vacancies occurring in this Board shall be filled by the Superintendent of the Midvale Steel Company.

Fees and Dues.

Each member of this Association shall pay an entrance fee of fifty (50) cents; and weekly dues amounting to five (5) cents.

No dues shall be exacted from any member of the Association for any week in which he earns no wages.

Each member shall, upon joining the Association, give to the Treasurer of the Midvale Steel Company a power of attorney in such form as shall amount to an assignment of his wages *pro tanto*, authorising him to take from his (the member's) weekly wages the sum of fifty-five (55) cents, for that current week, and five (5) cents per week for each week thereafter; also to retain the sum of fifty (50) cents from his wages whenever the Treasurer of the Midvale Steel Company shall receive from the President of the Association a request to deduct from the wages of each member of the Association fifty (50) cents, on account of a benefit to be paid upon the death of a member. All moneys deducted or retained from the wages of members of the Association by the Treasurer of the Midvale Steel Company shall be delivered weekly to the Treasury of the Association.

Any member losing his right of membership in consequence of leaving or being discharged from the services of the Midvale Steel Company can, if reinstated in said service, again become a member of the Association upon filing a new application, as required in Article II., Section 2.

Any member of the Association losing his rights of membership in consequence of leaving or being discharged from the service of the Midvale Steel Company (without having drawn any benefits from the Association), within thirty calendar days after the date of his employment, shall have returned to him the sum of fifty (50) cents paid as entrance fee at the time of his joining the Association, which sum he must again pay into the Association as an entrance fee at any future time he may again be employed by the Company. If, however, any member loses his right of membership in consequence of leaving or being discharged at a date later than thirty calendar days after the date of his employment, his entrance fee to

the Association of fifty cents will not be returned to him: but in this case, if, at any future time, he is again employed by the Company, and, consequently, becomes a member of the Association, he will not be obliged to pay an entrance fee.

Benefits.

The weekly benefits to be awarded during each three (3) months shall be determined upon by a majority of the Trustees present at their meetings in January, April, July and October; and in case of a failure at any meeting to designate, the amount theretofore existing shall continue; the sums so determined upon to be based upon the financial condition of the Association at the time of such meeting: Provided, That the weekly benefits shall not exceed five (5) dollars per week. This action of the Trustees shall be published to the members by the Secretary. Benefits shall be paid, *pro rata*, for fractions of a week lost through accident in the works: Provided, That no benefits shall be paid for less than two consecutive days so lost.

In the event of any member becoming disabled or incapacitated for service by an accident in the works, the Trustees shall draw an order upon the Treasurer for the amount of benefits herein provided. In such case the amount should be paid to the member disabled; and in all cases the settlement shall be made as soon as practicable after disability occurs; but not more than sixty (60) dollars shall be paid to any member for disability caused by one accident, unless in case of serious injury and by a unanimous vote of the Trustees present. In case any member be injured by an accident in the works, and die within six (6) months thereafter, and it be proved to the satisfaction of the Trustees that his death was caused by and was the result of such accident, the Trustees or a majority of them shall, through their President, request the Treasurer of the Midvale Steel Company to deduct fifty (50) cents from the wages of each member of the Association. In case of death of a member of the Midvale Beneficial Association, after having been a member of the Association for 24 consecutive months the Trustees, or a majority of them may, at their option and with the approval of the Superintendent of the Midvale Steel Company, through their President, request the Treasurer of the Midvale Steel Company to deduct fifteen (15) cents from the wages of each member of the Association. In case of death of a member, after having been a member of the Association for five (5) consecutive years, the sum of two hundred and fifty ($250) dollars shall be paid from the treasury of the Midvale Beneficial Association, in addition to the death assessment, to the beneficiary named upon the deceased member's application for membership, if the Trustees, or a majority of them, decide that the Association's financial condition admits of it. They shall also order, as hereinafter provided, that the Treasurer of the Association shall pay the amount so obtained to the beneficiary named upon the deceased member's application for membership. Members may at any time or times by writings filed under their hands and seals

revoke the designations of beneficiaries named in their applications, during the life of such beneficiaries, and appoint new beneficiaries, and they may reappoint new beneficiaries from time to time, in which event or events the benefits herein declared to be payable to the beneficiaries named upon deceased member's applications shall be payable to the persons designated in the new applications in force upon the death of the respective members. But no revocation of a prior appointment and no new appointment shall be operative or effective unless the same is in writing under the hand and seal of the member, witnessed by two persons, and assented to by an officer of the Association and the same lodged with the Association.

The moneys which shall become due and payable under the provisions of these By-Laws shall be payable only to the member himself, or to his nominee in case of death; and shall not be subject to or affected by any attachment or execution process whatsoever against such disabled member or his nominee.

The Trustees shall decide at a stated or special meeting whether the accident has been sufficient to cause disability or death. The certificate of a physician, considered by the Trustees to be in good standing, may be sufficient evidence of the fact. The vote of a majority of the Trustees present at a meeting shall be final and conclusive as to the rights of any claimant.

All orders drawn for benefits must be signed by not less than three (3) of the Trustees, and shall be countersigned by the Secretary of the Association.

All men injured in the works must notify the Secretary of the Association not later than the day following the injury and must obey the doctor's instructions in reporting for examination, using the remedies prescribed and going to the hospital if requested. No benefits will be paid unless the above instructions are carried out.

Certificate of Membership.

No...........

Philadelphia..................................190

This is to certify, That... residing .... having made application in due form for membership in the Midvale Beneficial Association, and having promised and agreed to be bound by the By-Laws of the same; said application has been approved by the Trustees of said Association, and that from this date he is entitled to all benefits accruing to members of said Association as provided for in said By-Laws.

....

President.

....

Secretary.

APPENDIX No. XV.

THE MIDVALE STEEL COMPANY'S GENERAL RULES.

1. The ordinary hours in these Works will be as follows: Day turn, from 6.30 a.m. to 12 m.; from 12.30 p.m. to 5.10 p.m. Saturdays, 12 m. Night turn, from 5.30 to 11.30 p.m.; from 12 a.m. to 6 a.m.; Saturday nights excepted. The whistle will blow at above hours; every man must be at his post and at work from whistle blow to whistle blow. All employés are expected to hold themselves in readiness to work Saturday afternoons and nights, and also overtime, upon occasion, when specially notified so to do by the foreman under special orders issued by any head or heads of Departments or the Superintendent.

2. All employés must be on hand every day unless laid off or excused. Any man tardy or absent without permission may be fined in an amount or amounts at the discretion of the Superintendent. In case of two days' absence without notification sent to the Timekeeper, ten hours' wages will be deducted from the time made.

3. In case of absence at night without notification to the Timekeeper before 3 p.m. of same day, five hours' wages will be deducted from time made. On Saturday night, Sunday and Sunday night said notification must be given before 12 m. Saturday.

4. Any man absent on Thursday morning or night, or morning or night after pay-day, without being excused by the head of his Department, will be fined five hours' pay.

5. Every man is required to give three days' notice to the Timekeeper of his intention to leave the employ of the Company. Any workman quitting the Company's employ without giving such full three days' notice, shall forfeit one day's pay, and the same shall become the property of the Company, and no right of action shall exist in the workman for recovery of the same.

6. Every man shall keep the tools and the specific property in his charge or with which he is working, clean and in good order. Men in charge of machines or tools must not leave them while running. Damage to or defects in implements, tools, machines, work in progress, or other property of the Company, and the necessity for repairs thereto, must be promptly reported in writing and signed by the workman using the same, to the head of his Department. No promise to repair, or instructions given to continue work pending repairs, shall be binding upon the Company unless made by the head of a department, after notice in writing of the need for repairs.

7. Any damage done to tools, implements, machines, or work in progress, and to other property of the Company, will be charged to the person last using the same, or last engaged upon the work, unless he has previously reported in writing the said damage as existing. The

damage in such case shall be assessed by the head of the Department or the Superintendent of the Works, and there shall be no appeal from such assessment.

The amount of such assessment may be deducted from the workman's wages. Committing nuisance about the Works, or the injury or defacement of the Company's property, sleeping or lying down during working hours, or bringing intoxicating liquors into the Works, will be punished rigorously by a fine at the discretion of the Superintendent, or by discharge of the workman.

8. Smoking is prohibited in the Works except between the following hours: 6 a.m. to 6.30 a.m., 12 m. to 1 p.m., 5.10 p.m. to 5.30 p.m., 11.30 p.m. to 12.30 a.m. At no time will smoking be allowed in the several departments where specially prohibited.

9. The foreman of a shop or gang will be held responsible for the general order of his premises; the driver of a machine, tool, hammer, engine, pump, crane, etc., for its condition in respect to neatness and proper care.

10. The foreman of a shop or gang must exact obedience to his own orders, and to the rules of the Works. It will be his duty to report any violation of these rules to the Superintendent.

11. No man will be allowed to use the tools of a shop in which he does not belong, or to take them from their proper places, or to use or start a machine tool, or machine, hammer, engine, pump, crane, etc., unless he does so under the direction of the foreman of the shop in which it belongs, or unless he is employed to run the same.

12. Tools taken from their proper places to be used elsewhere in the shops or yards, must be put back where they belong when no longer in use. Any litter or disorder necessarily left after a job must be reported to the foreman of the yard to be removed.

13. Any employé violating any of the rules of the Midvale Steel Company will be fined in an amount or amounts according as hereinbefore provided, and if not definitely provided herein, at the discretion of the head of the Department or the Superintendent of the Works.

Continuance in the employ of the Company after being subjected to a fine or assessment for violation of rules of the Company, or damage to work, tools, or property of the Company, shall be an acknowledgment on part of the employé of acceptance of same, and in consideration of such further employment the employé shall have no further right or claim for the money represented by said fine or assessment.

14. Additional special rules governing the operation of the Works, or of particular Departments thereof, and the conduct of employés, may be made and promulgated from time to time, and workmen are expected to obey the same. The acceptance of employment with the Company shall be considered as an agreement to abide by all the above mentioned rules, and all other reasonable rules promulgated, and to be promulgated; and the continuance of every employé in the Company's employ shall be considered as dependent upon a strict obedience thereto.

APPENDIX No. XVI.

THE MIDVALE STEEL COMPANY.

Locomotive Tire Prices.

In reply to your esteemed favour of.................we take pleasure in quoting the following prices on LOCOMOTIVE TIRES of regular sections.

MIDVALE OPEN-HEARTH BRAND.

Tires.	Price in Rough.	Price Bored.	Price Bored and Grooved for Retaining Rings.
For 33-in. wheel centres and over	5c. per lb.	$5\frac{1}{2}$c. per lb.	6 cents per lb.
For 18-in. to 33-in. wheel centres	6c. per lb.	$6\frac{1}{4}$c. per lb.	

MIDVALE CRUCIBLE BRAND.

Tires.	Price in Rough.	Price Bored.	Price Bored and Grooved for Retaining Rings.
For 33-in. wheel centres and over	7c. per lb.	$7\frac{1}{2}$c. per lb.	8 cents per lb.
For 18-in. to 33-in. wheel centres	8c. per lb.	$8\frac{1}{4}$c. per lb.	

Retaining Rings, Rough, 8c. per lb. Finished, 12c. per lb.

These prices include delivery to points in the United States on or east of the Mississippi River, south of Minneapolis, or east of a line due north from Minneapolis, and in Canada, in bond at the following points: Montreal, St. John, St. Thomas, Levis, Port Huron, Ft. Gratiot, Kingston and Ottawa.

Weights of Tires.

We give below the approximate weights of tires in the rough, allowing for boring to fit wheel centres ranging from 25 in. diameter to 62 in. diameter, the widths and thicknesses being those most commonly used. We desire to impress upon our customers the importance of giving the finished diameter of wheel centre when ordering instead of the rough or finished inside diameter of tires; we can then either send the tires in the rough with enough metal on the

inside to allow for boring and shrinkage, or bore them with the right shrinkage allowance, as the case may be.

TABLE OF WEIGHTS, 3 in. THICK.

Size of Wheel Centre.	Flange Tires.		Plain Tires.	
	5½ in. Wide.	5¾ in. Wide.	6 in. Wide.	6½ in. Wide.
in.	lbs.	lbs.	lbs.	lbs.
25	461	481	469	508
26	477	498	485	526
27	494	515	502	544
28	510	532	518	562
29	527	549	535	580
30	543	566	552	599
31	559	584	569	617
32	575	601	585	635
33	592	618	602	642
34	608	635	618	671
35	624	652	635	689
36	641	669	651	707
37	657	686	668	725
38	673	703	684	743
39	690	720	701	761
40	706	737	717	779
41	722	754	734	797
42	739	771	751	815
43	755	789	768	833
44	771	806	785	851
45	788	823	802	869
46	804	840	819	887
47	821	857	835	905
48	837	874	851	923
49	854	891	868	941
50	870	908	885	960
51	886	925	901	978
52	903	942	918	996
53	919	960	935	1014
54	935	977	951	1032
55	952	994	968	1050
56	968	1011	985	1068
57	985	1028	1002	1086
58	1001	1045	1018	1104
59	1018	1062	1033	1122
60	1034	1079	1051	1140
61	1050	1096	1068	1158
62	1067	1113	1015	1176

TABLE OF WEIGHTS, 3½ in. THICK.

Size of Wheel Centre.	Flange Tires.		Plain Tires.	
	5½ in. Wide.	5¾ in. Wide	6 in. Wide.	6½ in. Wide
in	lbs.	lbs.	lbs.	lbs.
25	542	570	550	597
26	561	590	569	618
27	580	610	588	639
28	599	630	608	660
29	618	650	627	681
30	637	670	646	702
31	656	690	666	723
32	675	710	685	747
33	694	730	704	765
34	713	750	723	786
35	732	770	743	807
36	751	790	762	828
37	770	810	781	848
38	789	830	801	869
39	808	850	820	890
40	827	870	839	911
41	846	890	859	932
42	865	910	878	953
43	884	930	897	974
44	903	950	917	995
45	932	970	936	1016
46	940	990	955	1037
47	959	1010	975	1058
48	978	1030	994	1079
49	997	1050	1013	1100
50	1016	1070	1033	1121
51	1035	1090	1052	1142
52	1054	1110	1071	1163
53	1073	1130	1091	1184
54	1092	1150	1110	1205
55	1111	1170	1129	1226
56	1130	1190	1149	1247
57	1149	1210	1168	1268
58	1168	1230	1187	1289
59	1187	1250	1207	1310
60	1206	1270	1226	1331
61	1225	1290	1245	1352
62	1244	1310	1265	1372

APPENDIX No. XVII.

MIDVALE STEEL COMPANY.

Information to Users of Tires.

We manufacture regularly four grades of each of our brands of tire metal, and while all grades of the same brand are of the same quality, they vary in hardness, as is shown by the results of chemical and physical tests made in the metal of every heat cast before it is used. The four grades are distinguished as follows:—

Grade.	Tensile Strength per Square inch.	Extension in 4 inches.	Proposed Uses.
No. 1. ..	100,000 to 110,000 lbs.	18 to 14 %	For High-speed Passenger Engines, usually 4 tires to a set, and about 54 inches and above inside diameter.
No. 2. ...	110,000 to 120,000 lbs.	14 to 11 %	For Mogul and Consolidation and small Passenger Engines, Tires about 40 inches and below 54 inches inside diameter.
No. 3. ...	120,000 to 130,000 lbs.	11 to 8 %	For switching Engines, and for Mogul and Consolidation and 4-wheel Engines whose tires are less than 40 inches inside diameter.
No. 4. ...	130,000 to 140,000 lbs.	8 to 5 %	For Switching Engines, where extra Hard Tires are needed.

The above column of "Proposed Uses" indicates, in general, what we consider the best application of our several grades of tire metal to the various classes of service and sizes of tires. It will be seen that we assume that, other things being equal, the hardness of the metal can, with safety, be increased as the diameters of the tires diminish.

We would request our customers, when ordering tires, to state on what class of engine and in what kind of service the tires are to be used. By referring to the above table, also, our customers may themselves indicate, if they see fit to do so, the grade of metal of which they may prefer to have any given tires made. This will give them opportunity to determine, by experiment, the hardness of tires best adapted to given purposes.

As regards the breaking of tires:—we may add, that it is frequently caused by allowing an excessive amount of shrinkage and that too

much care cannot be exercised in boring tires and in turning centres to exactly the dimensions desired. We recommend as a safe allowance for shrinkage, one-eightieth of an inch to the foot of inside diameter of tire; and think this is sufficient, if the boring and turning are accurately done. Please refer to the table on the inside page.

Any statistics which Railway Managers may be able to give us, containing records of the wear of our tires, with their Midvale numbers, and any particulars in regard to the nature of service, etc., will be of great value in enabling us to meet and fill the requirements of consumers of tires.

THE MIDVALE STEEL COMPANY.

Table of Shrinkages.

Size of Centre.	Shrinkage.	Bored Size of Tire.	Size of Centre.	Shrinkage.	Bored Size of Tire.
in.	in.	in.	in.	in.	in.
20	·021	19·979	53	·055	52·945
21	·022	20·978	54	·056	53·944
22	·023	21·977	55	·057	54·943
23	·024	22·976	56	·058	55·942
24	·025	23·975	57	·059	56·941
25	·026	24·974	58	·060	57·940
26	·027	25·973	59	·061	58 939
27	·028	26·972	60	063	59·937
28	029	27·971	61	·064	60·936
29	·030	28·970	62	·065	61·935
30	·031	29·969	63	·066	62 934
31	·032	30 968	64	·067	63·933
32	·033	31·967	65	·068	64 932
33	·034	33·966	66	·069	65·931
34	·035	33·965	67	·070	66·930
35	·036	34·964	68	·071	67 929
36	·038	35·962	69	·072	68·928
37	·039	36·961	70	·073	69·927
38	·040	37·960	71	·074	70 926
39	·041	38·959	72	·075	71·925
40	·042	39·958	73	·076	72·924
41	·043	40·957	74	·077	73·923
42	·044	41·956	75	·078	74·922
43	·045	42·955	76	·079	75·921
44	·046	43·954	77	080	76·920
45	·047	44·953	78	·081	77·919
46	·048	45·952	79	·082	78·918
47	·049	46·951	80	·083	79·917
48	·050	47·950	81	·084	80·916
49	·051	48·949	82	·085	81·915
50	·052	49·948	83	·086	82·914
51	·053	50·947	84	·088	83·912
52	·054	51·946			

APPENDIX No. XVIII.

MIDVALE WORK FORM.

PIECE WORK RATE NO. ....

From Estimating Dep't...1

To..*Dep't.*

Mr...

Give the following price..........................

....

....

....

High rate...

If done in ....

Low rate..

....

....

....

....

Remarks.

....

....

....

....

Work to be done...

....

Amount of work ....

Order No........... ....*Drawing No.* ....

....

Signed.................................

APPENDIX No. XIX.

FOUNDRY LABOUR FORM AT WORKS OF W. SELLERS & COMPANY.

Iron Foundry,

Shop.........................Department..........................

.... 190... Register No............ Name.......................

Occupation.. Rate.................

Charge.		Change of Rate	Errors and Defects	Time on unfinished tickets bro' forward.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	Total Time.	D. W. Time.	P. W. Time.	Contract Price.	Amount Due.
No. or Order	No. of Ticket.											Unfinished Time.				

APPENDIX No. XX.

Prospectus of the United States Steel Corporation.

OFFICE OF J. P. MORGAN & CO.,

23, *Wall Street, New York, March* 2, 1901.

To the stockholders of Federal Steel Company, National Steel Company, National Tube Company, American Steel and Wire Company of New Jersey, American Tin Plate Company, American Steel Hoop Company, American Sheet Steel Company.

The United States Steel Corporation has been organised under the laws of the State of New Jersey, with power, among other things, to acquire the outstanding preferred stocks and common stocks of the companies above named and the outstanding bonds and stock of the Carnegie Company.

A syndicate, comprising leading financial interests throughout the United States and Europe, of which the undersigned are managers, has been formed by subscribers to the amount of 200,000,000 dols. (including among such subscribers the undersigned and many large stockholders of the several companies), to carry out the arrangement hereinafter stated, and to provide the sum in cash and the financial support required for that purpose. Such syndicate, through the undersigned, has made a contract with the United States Steel Corporation under which the latter is to issue and deliver its preferred stock, and its common stock, and its 5 per cent. gold bonds in consideration

for stocks of the above-named companies and bonds and stock of the Carnegie Company and the sum of 25,000,000 dols. in cash.

The syndicate has already arranged for the acquisition of substantially all the bonds and stock of the Carnegie Company, including Mr. Carnegie's holdings. The bonds of the United States Steel Corporation are to be used only to acquire bonds and 60 per cent. of the stock of the Carnegie Company.

The undersigned, in behalf of the syndicate, and on the terms and conditions hereinafter stated, offer, in exchange for the preferred stocks and common stocks of the companies above named, respectively, certificates for preferred stock and common stock of the United States Steel Corporation upon the basis stated in the following table, viz. :—

For each 100 dols. par value of stock of the class mentioned below, the amount set opposite thereto in preferred stock or common stock of United States Steel Corporation at par :

Name of company and class of stock.	Amount of new stock to be delivered in par value.	
	Preferred stock.	Common stock.
Federal Steel Company :		
Preferred stock	$110·00	—
Common stock	4·00	$107·50
American Steel and Wire Company of New Jersey :		
Preferred stock	117·50	—
Common stock	—	102·50
National Tube Company :		
Preferred stock	125·00	—
Common stock	8·80	125·00
National Steel Company :		
Preferred stock	125·00	—
Common stock	—	125·00
American Tin Plate Company :		
Preferred stock	125·00	—
Common stock	20·00	125·00
American Steel Hoop Company :		
Preferred stock	100·00	—
Common stock	—	100·00
American Sheet Steel Company :		
Preferred stock	100·00	—
Common stock	—	100·00

With reference to the last four companies, the aggregate amount of stocks so to be offered was arranged with the principal stockholders of those companies, who have requested the distribution of such amount among the four companies, to be made in the percentages above stated.

Proper adjustment will be made in respect of dividends upon all the deposited preferred stocks, so that the registered holders of receipts for such preferred stocks will receive the equivalent of dividends

thereon, at the rates therein provided, from the last dividend period up to April 1, 1901, from which date dividends on the preferred stock of the United States Steel Corporation are to begin to accrue. Deposited common stock must carry all dividends or rights to dividends declared or payable on or after March 1, 1901, and no adjustment or allowance will be made in respect thereof.

For the purpose of avoiding the necessity of interruption in the declaration and payment of dividends, when earned upon the common stock, concurrently with the payment of dividends upon the preferred stock, there has been inserted in the charter of the United States Steel Corporation a provision to the effect that whenever all quarterly dividends accrued upon the preferred stock for previous quarters shall have been paid, the board of directors may declare dividends on the common stock out of any remaining surplus or net profits.

Statements furnished to us by officers of the several companies above named and of the Carnegie Company show that the aggregate of the net earnings of all the companies for the calendar year 1900 was amply sufficient to pay dividends on both classes of the new stocks, besides making provisions for sinking funds and maintenance of properties. It is expected that by the consummation of the proposed arrangement the necessity of large deductions heretofore made on account of expenditure for improvements will be avoided, the amount of earnings applicable to dividends will be substantially increased, and greater stability of investment will be assured, without necessarily increasing the prices of manufactured products.

The certificates for stocks of the companies above named must be deposited, as stated below, in exchange for transferable receipts issued by the respective depositaries, for which application will be made for listing on the New York Stock Exchange. The deposited certificates must be accompanied by suitable assignments and powers of attorney in blank, duly executed, and having attached thereto the proper war revenue stamps, and also, if required, suitable assignments or transfers of all dividends or rights to dividends upon deposited common stocks declared or payable on or after March 1, 1901. Every deposit shall be upon the following further terms and conditions:

[illegible] The undersigned, acting in behalf of the syndicate, shall have [illegible] over the deposited certificates, including power to deliver [illegible] under said contract to the United States Steel Corporation, [illegible] of the issue of preferred stock and common stock of [illegible].

[illegible] certificates for shares of the United States Steel Corporation [illegible] depositors, shall be delivered at an office or at offices, [illegible] New York to be designated by the undersigned by [illegible] at least two newspapers in the City of New York. [illegible] may be issued in the names of the respective holders [illegible] entitled thereto, or may be issued in such other names [illegible] may select, in which event they shall be indorsed [illegible] at the time of delivery. The undersigned, at [illegible] temporary certificates for such shares pending [illegible] very of engraved certificates.

[illegible] to the deposit hereunder of two-thirds in

amount of all outstanding shares of the capital stock of any one or more of the above-named companies (which two-thirds in each instance shall include two-thirds of the outstanding preferred stock of such company), the undersigned, in their discretion, may withdraw the offer herein made to depositors of shares of any such company of whose capital stock two-thirds shall not have been deposited, and in such case no act or notice of withdrawal shall be required other than advertisement thereof at least once in each of two daily newspapers in the City of New York. Upon any such withdrawal, the deposited shares of such company shall be returned, without charge upon surrender of the respective receipts issued therefor. The undersigned, in their discretion, may consummate the proposed transaction as to the stocks of any companies herein named, irrespective of the deposit of the stocks of any other company or of any withdrawal as to any other company.

4. The undersigned are authorised to proceed with the proposed transaction whenever, in their sole judgment, a sufficient amount of the stocks of said companies, or of any of them, shall have been deposited. They reserve the right, at any time in their discretion, to wholly abandon the transaction and to withdraw their offer herein contained, as to all the depositors, by publication of notice of such withdrawal in two daily newspapers in the City of New York; and in that event all the deposited shares shall be returned without charge upon surrender of the respective receipts therefor. In case of any such withdrawal of the offer hereunder as to all or to any depositors, such depositors shall have no claim against the undersigned, and shall only be entitled to receive their deposited securities upon surrender of the respective receipts therefor.

5. The authorised issue of capital stock of the United States Steel Corporation presently provided for in said contract is 850,000,000 dols., of which one-half is to be seven per cent. cumulative preferred stock and one-half is to be common stock. The company will also issue its five per cent. gold bonds to an aggregate amount not exceeding 304,000,000 dols. In case less than all of the bonds and stock of the Carnegie Company or less than all of the stocks of the other companies above referred to shall be acquired the amounts of bonds and stocks to be issued will be reduced as provided in said contract.

The forms of the new bonds and of the indenture securing the same, and of the certificates for the new preferred and common shares, and the entire plan of organisation and management of the United States Steel Corporation, shall be determined by J. P. Morgan & Co. Every depositor shall accept in full payment and exchange for his deposited stock the shares of the capital stock of the United States Steel Corporation, to be delivered at the rates above specified, in respect of the stock by him so deposited; and no depositor or holder of any receipt issued hereunder shall have any interest in the disposition of any other of the shares of stock, or of the bonds of the United States Steel Corporation, by it to be issued and delivered to or for account of the syndicate or of any proceeds thereof. All shares of the United States Steel Corporation deliverable to or for account of the syndicate, which shall not be required for the acquisition of the stock of the Carnegie Company or for delivery

to depositors under the terms of this circular, are to be retained by and to belong to the syndicate.

6. The respective depositaries may make all such rules as shall be approved by the undersigned governing the transfer and registration of receipts for deposited shares and for the closing of the transfer books for such receipts for any purpose. The undersigned shall not be responsible for any default of any depositary.

7. Each deposit hereunder shall be irrevocable, and shall operate as a separate and independent agreement, and as a transfer of the interest of the depositors to the undersigned on the terms hereof.

8. Deposits must be made with the following depositaries, respectively:

Federal Steel preferred and common stock with Colonial Trust Company, New York, or with Old Colony Trust Company, Boston.

National Tube preferred and common stock with Morton Trust Company, New York, or with Kidder, Peabody & Co., Boston.

American Steel and Wire preferred and common stock with Standard Trust Company, New York, or with Guaranty Trust Company, New York.

National Steel preferred and common stock with Central Trust Company, New York.

American Tin Plate preferred and common stock with Mercantile Trust Company, New York.

American Sheet Steel preferred and common stock with Farmers' Loan and Trust Company, New York.

American Steel Hoop preferred and common stock with New York Security and Trust Company, New York.

The undersigned reserve the right in their discretion to terminate the privilege of deposit hereunder at an earlier date upon two days' notice, to be given by publication at least once in two daily newspapers in New York City.

It is proper to state that J. P. Morgan & Co. are to receive no compensation for their services as syndicate managers beyond a share in any sum which ultimately may be realised by the syndicate.

J. P. MORGAN & CO.,
Syndicate Managers.

APPENDIX XXI.

Amended Certificate of Incorporation of United States Steel Corporation.

We, the undersigned, in order to form a corporation for the purposes hereinafter stated, under and pursuant to the provisions of the Act of the Legislature of the State of New Jersey, entitled, "An Act concerning Corporations (revision of 1896)," and the Acts amendatory thereof and supplemental thereto, do hereby certify as follows:

I. The name of the corporation is United States Steel Corporation.

II. The location of its principal office in the State of New Jersey is at No. 51, Newark Street, in the City of Hoboken, County of Hudson.

The name of the agent therein and in charge thereof, upon whom process against the Corporation may be served, is Hudson Trust Company. Said office is to be the registered office of said Corporation.

III. The objects for which the Corporation is formed are:

To manufacture iron, steel, manganese, coke, copper, lumber, and other materials, and all or any articles consisting or partly consisting of iron, steel, copper, wood, or other materials, and all or any products thereof.

To acquire, own, lease, occupy, use, or develop any lands containing coal or iron, manganese, stone, or other ores, or oil, and any woodlands, or other lands, for any purpose of the Company.

To mine, or otherwise to extract or remove, coal, ores, stone, and other minerals and timber from any lands owned, acquired, leased, or occupied by the Company, or from any other lands.

To buy and sell, or otherwise to deal or to traffic in, iron, steel, manganese, copper, stone, ores, coal, coke, wood, lumber, and other materials, and any of the products thereof, and any articles consisting or partly consisting thereof.

To construct bridges, buildings, machinery, ships, boats, engines, cars, and other equipment, railroads, docks, slips, elevators, water works, gas works, and electric works, viaducts, aqueducts, canals and other waterways, and any other means of transportation, and to sell the same, or otherwise to dispose thereof, or to maintain and operate the same, except that the Company shall not maintain or operate any railroad or canal in the State of New Jersey.

To apply for, obtain, register, purchase, lease, or otherwise to acquire, and to hold, use, own, operate, and introduce, and to sell, assign, or otherwise to dispose of, any trade marks, trade names, patents, inventions, improvements, and processes used in connection with or secured under Letters Patent of the United States or elsewhere, or otherwise; and to use, exercise, develop, grant licenses in respect of or otherwise to turn to account any such trade marks, patents, licenses, processes, and the like, or any such property or rights.

To engage in any other manufacturing, mining, construction, or transportation business of any kind or character whatsoever, and to that end to acquire, hold, own, and dispose of any and all property, assets, stocks, bonds, and rights of any and every kind; but not to engage in any business hereunder which shall require the exercise of the right of eminent domain within the State of New Jersey.

To acquire by purchase, subscription, or otherwise, and to hold or to dispose of stocks, bonds, or any other obligations of any corporation formed for or then or theretofore engaged in or pursuing any one or more of the kinds of business, purposes, objects, or operations above indicated, or owning or holding any property of any kind herein mentioned; or of any corporation owning or holding the stocks or the obligations of any such corporation.

To hold for investment, or otherwise to use, sell, or dispose of any stock, bonds, or other obligations of any such other corporation; to aid in any manner any corporation whose stock, bonds, or other obligations are held or are in any manner guaranteed by the Company, and to do any other acts or things for the preservation, protection, improve-

ment, or enhancement of the value of any such stock, bonds, or other obligations, or to do any acts or things designed for any such purpose; and, while owner of any such stock, bonds, or other obligations, to exercise all the rights, powers, and privileges of ownership thereof, and to exercise any and all voting power thereon.

The business or purpose of the Company is from time to time to do any one or more of the acts and things herein set forth; and it may conduct its business in other States and in the Territories and in foreign countries, and may have one office or more than one office, and keep the books of the Company outside of the State of New Jersey, except as otherwise may be provided by law; and may hold, purchase, mortgage, and convey real and personal property either in or out of the State of New Jersey.

Without in any particular limiting any of the objects and powers of the Corporation, it is hereby expressly declared and provided that the Corporation shall have power to issue bonds and other obligations in payment for property purchased or acquired by it, or for any other object in or about its business; to mortgage or pledge any stocks, bonds, or other obligations, or any property which may be acquired by it, to secure any bonds or other obligations by it issued or incurred; to guarantee any dividends or bonds or contracts or other obligations; to make and perform contracts of any kind and description; and in carrying on its business or for the purpose of attaining or furthering any of its objects to do any and all other acts and things, and to exercise any and all other powers which a co-partnership or natural person could do and exercise, and which now or hereafter may be authorised by law.

IV. The total authorised capital stock of the Corporation is 1,100,000,000 dols., divided into 11,000,000 shares of the par value of 100 dols. each. Of such total authorised capital stock, 5,500,000 shares, amounting to 550,000,000 dols., shall be preferred stock, and 5,500,000 shares, amounting to 550,000,000 dols., shall be common stock.

From time to time the preferred stock and the common stock may be increased according to law, and may be issued in such amounts and proportions as shall be determined by the board of directors and as may be permitted by law.

The holders of the preferred stock shall be entitled to receive when and as declared, from the surplus or net profits of the Corporation, yearly dividends at the rate of 7 per cent. per annum, and no more, payable quarterly on dates to be fixed by the by-laws. The dividends on the preferred stock shall be cumulative, and shall be payable before any dividend on the common stock shall be paid or set apart: so that if in any year dividends amounting to 7 per cent. shall not have been paid thereon, the deficiency shall be payable before any dividends shall be paid upon or set apart for the common stock.

Whenever all cumulative dividends on the preferred stock for all previous years shall have been declared and shall have become payable, and the accrued quarterly instalments for the current year shall have been declared, and the company shall have paid such cumulative dividends for previous years and such accrued quarterly instalments, or shall have set aside from its surplus or net profits

a sum sufficient for the payment thereof, the board of directors may declare dividends on the common stock, payable then or thereafter, out of any remaining surplus or net profits.

In the event of any liquidation or dissolution or winding up (whether voluntary or involuntary) of the corporation, the holders of the preferred stock shall be entitled to be paid in full both the par amount of their shares and the unpaid dividends accrued thereon before any amount shall be paid to the holders of the common stock; and after the payment to the holders of the preferred stock of its par value, and the unpaid accrued divendends thereon, the remaining assets and funds shall be divided and paid to the holders of the common stock according to their respective shares.

V. The names and post-office addresses of the incorporators, and the number of shares of stock for which severally and respectively we do hereby subscribe (the aggregate of our said subscriptions, being 3,000 dols., is the amount of capital stock with which the corporation will commence business), are as follows:—

Name.	Post-office address.	Number of Shares.	
		Preferred stock.	Common stock.
Charles C. Cluff......	51 Newark street, Hoboken, N.J.........	5	5
William J. Curtis.....	.........do.....................................	5	5
Charles MacVeagh...	........do.....................	5	5

VI. The duration of the corporation shall be perpetual.

VII. The number of directors of the company shall be fixed from time to time to the by-laws; but the number, if fixed at more than three, shall be some multiple of three. The directors shall be classified with respect to the time for which they shall severally hold office by dividing them into three classes, each consisting of one-third of the whole number of the board of directers. The directors of the first class shall be elected for a term of one year; the directors of the second class for a term of two years; and the directors of the third class for a term of three years; and at each annual election the successors to the class of directors whose terms shall expire in that year shall be elected to hold office for the term of three years, so that the term of office of one class of directors shall expire in each year.

The number of the directors may be increased as may be provided in the by-laws. In case of any increase of the number of the directors, the additional directors shall be elected, as may be provided in the by-laws, by the directors or by the stockhelders at an annual or special meeting; and one-third of their number shall be elected for the then unexpired portion of the term of the directors of the first class, one-third of their number for the unexpired portion of the term of the directors of the second class,

and one-third of their number for the unexpired portion of the term of the directors of the third class, so that each class of directors shall be increased equally.

In case of any vacancy in any class of directors through death, resignation, disqualification, or other cause, the remaining directors, by affirmative vote of a majority of the board of directors, may elect a successor to hold office for the unexpired portion of the term of the director whose place shall be vacant, and until the election of a successor.

The board of directors shall have power to hold their meetings outside of the State of New Jersey at such places as from time to time may be designated by the by-laws or by resolution of the board. The by-laws may prescribe the number of directors necessary to constitute a quorum of the board of directors, which number may be less than a majority of the whole number of the directors.

Unless authorised by votes given in person or by proxy by stockholders holding at least two-thirds of the capital stock of the corporation, which is represented and voted upon in person or by proxy at a meeting specially called for that purpose or at an annual meeting; the board of directors shall not mortgage or pledge any of its real property or any shares of the capital stock of any other corporation; but this prohibition shall not be construed to apply to the execution of any purchase-money mortgage or any other purchase-money lien. As authorised by the Act of the Legislature of the State of New Jersey, passed March 22nd, 1901, amending the 17th section of the Act concerning corporations (revision of 1826), any action which theretofore required the consent of the holders of two-thirds of the stock at any meeting after notice to them given, or required their consent in writing to be filed, may be taken upon the consent of and the consent given and filed by the holders of two-thirds of the stock of each class represented at such meeting in person or by proxy.

Any officer elected or appointed by the board of directors may be removed at any time by the affirmative vote of a majority of the whole board of directors. Any other officer or employé of the company may be removed at any time by vote of the board of directors, or by any committee or superior officer upon whom such power of removal may be conferred by the by-laws, or by vote of the board of directors.

The board of directors, by the affirmative vote of a majority of the whole board, may appoint from the directors an executive committee, of which a majority shall constitute a quorum; and to such extent as shall be provided in the by-laws, such committee shall have and may exercise all or any of the powers of the board of directors, including power to cause the seal of the corporation to be affixed to all papers that may require it.

The board of directors, by the affirmative vote of a majority of the whole board, may appoint any other standing committees, and such standing committees shall have and may exercise such powers as shall be conferred or authorised by the by-laws.

The board of directors may appoint not only other officers of

the company, but also one or more vice-presidents, one or more assistant treasurers, and one or more assistant secretaries; and to the extent provided in the by-laws, the persons so appointed respectively shall have and may exercise all the powers of the president, of the treasurer, and of the secretary, respectively.

The board of directors shall have power from time to time to fix and to determine and to vary the amount of the working capital of the company, and to direct and determine the use and disposition of any surplus or net profits over and above the capital stock paid in; and in its discretion the board of directors may use and apply any such surplus or accumulated profits in purchasing or acquiring its bonds or other obligations, or shares of its own capital stock, to such extent and in such manner and upon such terms as the board of directors shall deem expedient; but shares of such capital stock so purchased or acquired may be resold, unless such shares shall have been retired for the purpose of decreasing the company's capital stock, as provided by law.

The board of directors from time to time shall determine whether and to what extent, and at what times and places and under what conditions and regulations, the accounts and books of the corporation, or any of them, shall be open to the inspection of the stockholders, and no stockholder shall have any right to inspect any account or book or document of the corporation, except as conferred by statute or authorised by the board of directors, or by a resolution of the stockholders.

Subject always to by-laws made by the stockholders, the board of directors may make by-laws, and, from time to time, may alter, amend, or repeal any by-laws; but any by-laws made by the board of directors may be altered or repealed by the stockholders at any annual meeting, or at any special meeting, provided notice of such proposed alteration or repeal be included in the notice of the meeting.

In witness whereof we have hereunto set our hands and seals the 23rd day of February, 1901.

CHARLES C. CLUFF. [SEAL.]
WILLIAM J. CURTIS. [SEAL.]
CHARLES MACVEAGH. [SEAL.]

Signed, sealed, and delivered in the presence of—
FRANCIS LYNDE STETSON.
VICTOR MORAWETZ.

STATE OF NEW JERSEY, *County of Hudson, ss:*

Be it remembered that on this 23rd day of February, 1901, before the undersigned, personally appeared Charles C. Cluff, William J. Curtis, and Charles MacVeagh, who, I am satisfied, are the persons named in and who executed the foregoing certificate; and I having first made known to them and to each of them the contents thereof, they did each acknowledge that they signed, sealed, and delivered the same as their voluntary act and deed.

GEO. HOLMES,
Master in Chancery of New Jersey.

APPENDIX No. XXII.

BY-LAWS OF UNITED STATES STEEL CORPORATION.

Article I.—Stockholders.

SECTION 1. *Annual Meeting.*—A meeting of the stockholders of the company shall be held annually at the principal office of the company in the State of New Jersey, at twelve o'clock noon on the third Monday in February in each year, if not a legal holiday, and if a legal holiday then on the next succeeding Monday not a legal holiday, for the purpose of electing directors, and for the transaction of such other business as may be brought before the meeting.

It shall be the duty of the secretary to cause notice of each annual meeting to be published once in each of the four calendar weeks next preceding the meeting in at least one newspaper in each of the following places: Jersey City, N.J.: New York, N.Y.; Chicago, Ill.; and Pittsburg, Pa. Nevertheless, a failure to publish such notice, or any irregularity in such notice, or in the publication thereof, shall not affect the validity of any annual meeting, or of any proceedings at any such meeting.

SEC. 2. *Special Meetings.*—Special meetings of the stockholders may be held at the principal office of the company in the State of New Jersey whenever called in writing, or by vote, by a majority of the board of directors.

Notice of each special meeting, indicating briefly the object or objects thereof, shall by the secretary be published once in each of the four calendar weeks next preceding the meeting in at least one newspaper in each of the following places: Jersey City, N.J., New York, N.Y., Chicago, Ill., and Pittsburg, Pa. Nevertheless, if all the stockholders shall waive notice of a special meeting, no notice of such meeting shall be required; and whenever all the stockholders shall meet in person or by proxy, such meeting shall be valid for all purposes without call or notice, and at such meeting any corporate action may be taken.

SEC. 3. *Quorum.*—At any meeting of the stockholders the holders of one-third of all of the shares of the capital stock of the company, present in person or represented by proxy, shall constitute a quorum of the stockholders for all purposes, unless the representation of a larger number shall be required by law, and in that case, the representation of the number so required shall constitute a quorum.

If the holders of the amount of stock necessary to constitute a quorum shall fail to attend in person or by proxy at the time and place fixed by these by-laws for an annual meeting, or fixed by notice as above provided for a special meeting called by the directors, a majority in interest of the stockholders present in person or by proxy, may adjourn from time to time, without notice other than by announcement at the meet-

ing until holders of the amount of stock requisite to constitute a quorum, shall attend. At any such adjourned meeting at which a quorum shall be present any business may be transacted which might have been transacted at the meeting as originally notified.

SEC. 4. *Organisation.*—The president, and in his absence the chairman of the executive committee, shall call meetings of the stockholders to order, and shall act as chairman of such meetings. The board of directors may appoint any stockholder to act as chairman of any meeting in the absence of the president and of the chairman of the executive committee.

The secretary of the company shall act as secretary at all meetings of the stockholders, but in the absence of the secretary at any meeting of the stockholders the presiding officer may appoint any person to act as secretary of the meeting.

SEC. 5. *Voting.*—At each meeting of the stockholders every stockholder shall be entitled to vote in person, or by proxy appointed by instrument in writing, subscribed by such stockholder or by his duly authorised attorney, and delivered to the inspectors at the meeting; and he shall have 1 vote for each share of stock standing registered in his name at the time of the closing of the transfer books for said meeting. The votes for directors, and, upon demand of any stockholder, the votes upon any question before the meeting, shall be by ballot.

At each meeting of the stockholders a full, true, and complete list, in alphabetical order, of all the stockholders entitled to vote at such meeting, and indicating the number of shares held by each, certified by the secretary or by the treasurer, shall be furnished. Only the persons in whose names shares of stock stand on the books of the company at the time of the closing of the transfer books for such meeting, as evidenced by the list of stockholders so furnished, shall be entitled to vote in person or by proxy on the shares so standing in their names.

Prior to any meeting, but subsequent to the time of closing the transfer books for such meeting, any proxy may submit his powers of attorney to the secretary or to the treasurer for examination. The certificate of the secretary or of the treasurer as to the regularity of such powers of attorney and as to the number of shares held by the persons who severally and respectively executed such powers of attorney shall be received as *prima facie* evidence of the number of shares represented by the holder of such powers of attorney for the purpose of establishing the presence of a quorum at such meeting, and of organising the same, and for all other purposes.

SEC. 6. *Inspectors.*—At each meeting of the stockholders the polls shall be opened and closed, the proxies and ballots shall be received and be taken in charge, and all questions touching the qualification of voters and the validity of proxies and the acceptance or rejection of votes shall be decided by three inspectors. Such inspectors shall be appointed by the board of directors before or at the meeting, or, if no such appointment shall have been made, then by the presiding officer of the meeting. If for any reason any of the inspectors previously appointed shall fail to attend or refuse or be unable to serve, inspectors in place of any so failing to attend or refusing or unable to attend, shall be appointed in like manner.

Article II.—Board of Directors.

SEC. 1. *Number, Classification, and Term of Office.*—The business and the property of the company shall be managed and controlled by the board of directors.

As provided in the certificate of incorporation, the directors shall be classified in respect of the time for which they shall severally hold office by dividing them into three classes, each class consisting of one-third of the whole number of the board of directors. The directors of the first class shall be elected for a term of one year, the directors of the second class shall be elected for a term of two years, and the directors of the third class shall be elected for a term of three years. At each annual election the successors to the directors of the class whose terms shall expire in that year shall be elected to hold office for the term of three years, so that the term of office of one class of directors shall expire in each year.

The number of directors shall be 24, but the number of directors may be altered from time to time by the alteration of these by-laws.

In case of any increase of the number of directors, the additional directors shall be elected by the directors then in office; one-third of such additional directors for the unexpired portion of the term of 1 year; one-third for the unexpired portion of the term of 2 years, and one-third for the unexpired portion of the term of 3 years, so that each class of directors shall be increased equally.

Every director shall be a holder of at least 1 share of the capital stock of the company. Each director shall serve for the term for which he shall have been elected, and until his successor shall have been duly chosen.

At all elections of the directors the polls shall remain open for at least 1 hour, unless every registered owner of shares has sooner voted in person or by proxy, or in writing has waived the statutory provision.

SEC. 2. *Vacancies.*- In case of any vacancy in the directors of any class through death, resignation, disqualification, or other cause, the remaining directors, by affirmative vote of a majority thereof, may elect a successor to hold office for the unexpired portion of the term of the director whose place shall be vacant, and until the election of his successor.

Such vacancies shall be filled upon and after nominations therefor shall have been made by the finance committee.

SEC. 3. *Place of Meeting, etc.*—The directors may hold their meetings and may have an office and keep the books of the company (except as otherwise may be provided for by law) in such place or places in the State of New Jersey or outside of the State of New Jersey as the board from time to time may determine.

SEC. 4. *Regular Meetings.*—Regular meetings of the board of directors shall be held monthly, on the first Tuesday of each month, if not a legal holiday, and if a legal holiday, then on the next succeeding Tuesday not a legal holiday. No notice shall be required for any such regular monthly meeting of the board.

SEC. 5. *Special Meetings.*—Special meetings of the board of directors shall be held whenever called by the president or by one-third of the directors for the time being in office.

The secretary shall give notice of each special meeting by mailing the

same at least two days before the meeting or by telegraphing the same at least one day before the meeting to each director, but such notice may be waived by any director. At any meeting at which every director shall be present, even though without any notice, any business may be transacted.

SEC. 6. *Quorum.*—A majority of the board of directors shall constitute a quorum for the transaction of business, but if at any meeting of the board there be less than a quorum present, a majority of those present may adjourn the meeting from time to time.

The affirmative vote of at least two-fifths of all the directors for the time being in office shall be necessary for the passage of any resolution.

SEC. 8. *Order of Business.*—At meetings of the board of directors business shall be transacted in such order as, from time to time, the board may determine by resolution.

At all meetings of the board of directors the president, or in his absence the chairman of the executive committee, or in the absence of both of these officers the chairman of the finance committee, shall preside.

SEC. 9. *Contracts.*—Inasmuch as the directors of this company are men of large and diversified business interests and are likely to be connected with other corporations with which from time to time this company must have business dealings, no contract or other transaction between this company and any other corporation shall be affected by the fact that directors of this company are interested in or are directors or officers of such other corporation if, at the meeting of the board, or of the committee of this company making, authorising, or confirming such contract or transaction there shall be present a quorum of directors not so interested ; and any director individually may be a party to or may be interested in any contract or transaction of this company provided that such contract or transaction shall be approved or be ratified by the affirmative vote of at least ten directors not so interested.

The board of directors, in its discretion, may submit any contract or act for approval or ratification at any annual meeting of the stockholders, or at any meeting of the stockholders called for the purpose of considering any such act or contract, and any contract or act that shall be approved or be ratified by the vote of the holders of a majority of the capital stock of the company which is represented in person or by proxy at such meeting (provided that a lawful quorum of stockholders be there represented in person or by proxy) shall be as valid and as binding upon the corporation and upon all the stockholders as though it had been approved or ratified by every stockholder of the corporation.

SEC. 10. *Compensation of Directors.*—For his attendance at any meeting of the board of directors or of any committee of the board every director shall receive an allowance of 10 cents for every mile travelled by him for attendance at such meeting and also the sum of $20 for attendance at each meeting. The same mileage allowance shall be made to any officer who by direction of the board or of the president shall attend any such meeting.

Article III.—Executive Committee and Finance Committee.

SEC. 1. The board of directors shall elect from the directors an executive committee and a finance committee, and shall designate for

each of those committees a chairman, who shall continue to be chairman of the committee during the pleasure of the board of directors.

The board of directors shall fill vacancies in the executive committee or in the finance committee by election from the directors, and at all times it shall be the duty of the board of directors to keep the membership of each of such committees full, with due regard to the qualifications for such membership indicated in this article of the by-laws.

All action by the executive committee or by the finance committee shall be reported to the board of directors at its meeting next succeeding such action, and shall be subject to revision or alteration by the board of directors; provided that no rights or acts of third parties shall be effected by any such revision or alteration.

The executive committee and the finance committee each shall fix its own rules of proceeding, and shall meet where and as provided by such rules or by resolution of the board of directors, but in every case the presence of a majority shall be necessary to constitute a quorum.

In every case the affirmative vote of a majority of all of the members of the committee shall be necessary to its adoption of any resolution.

The chairman and each of the members of the executive committee shall receive such compensation for their services as from time to time shall be fixed by the finance committee and be approved by the board of directors.

SEC. 2. The executive committee shall consist of six members besides the president and the chairman of the finance committee, each of whom, by virtue of his office, shall be a member of the executive committee. So far as practicable, each of the six elected members of the executive committee shall be a person having, or having had, personal experience in the conduct of one or the other of the branches of manufacture or mining, or of transportation in which the company is interested, and, so so far as practicable, the six elected members shall be taken equally from the three classes of directors. Unless otherwise ordered by the board of directors, each elected member of the executive committee shall continue to be a member thereof until the expiration of his term of office as a director.

During the intervals between the meetings of the board of directors the executive committee shall possess and may exercise all the powers of the board of directors in the management and direction of the manufacturing, mining, and transportation operations of the company, and of all other business and affairs (except the matters hereinafter assigned to the finance committee) in such manner as the executive committee shall deem best for the interests of the company, in all cases in which specific directions shall not have been given by the board of directors.

During the intervals between the meetings of the executive committee the chairman thereof shall possess and may exercise such of the powers vested in the executive committee as from time to time may be conferred upon him by resolution of the board of directors or of the executive committee.

SEC. 3. The finance committee shall consist of four members besides the president and the chairman of the executive committee, each of whom, by virtue of his office, shall be a member of the finance committee. So far as practicable, each of the four elected members of the finance

committee shall be a person of experience in matters of finance, and, so far as practicable, the four elected members shall be taken equally from the three classes of directors. Unless otherwise ordered by the board of directors, each elected member of the finance committee shall continue to be a member thereof until the expiration of his term of office as a director.

The finance committee shall have special and general charge and control of all financial affairs of the company. The general counsel, the treasurer, the auditor, and the secretary, and their respective offices shall be under the direct control and supervision of the finance committee.

During the intervals between the meetings of the board of directors the finance committee shall possess, and may exercise, all the powers of the board of directors in the management of the financial affairs of the company, including its purchases of property, and the execution of legal instruments with or without the corporate seal in such manner as said committee shall deem to be best for the interests of the company, in all cases in which specific directions shall not have been given by the board of directors.

During the intervals between the meetings of the finance committee, and subject to its review, the chairman thereof shall possess and may exercise any of the powers of the committee except as from time to time shall be otherwise provided by resolution of the board of directors, or of the finance committee, but not of the executive committee.

Except as otherwise provided by the by-laws, or by resolution of the board of directors, all salaries and compensations paid or payable by the company shall be fixed by the finance committee.

No director shall become a salaried employé of the company except by special vote of the finance committee.

Article IV.—Officers.

SEC. 1. *Officers.*—The executive officers of the company shall be a president, a vice-president, or more than one vice-president, a general counsel, a treasurer, a secretary, and an auditor, all of whom shall be elected by the board of directors.

The board of directors may appoint such other officers as they shall deem necessary, who shall have such authority and shall perform such duties as from time to time may be prescribed by the board of directors.

The powers and duties of the treasurer and secretary may be exercised and performed by the same person.

In its discretion the board of directors, by the vote of a majority thereof, may leave unfilled, for any such period as it may fix by resolution, any office except those of president, treasurer, secretary, and auditor.

All officers and agents shall be subject to removal at any time by the affirmative vote of a majority of the whole board of directors. All officers, agents, and employés, other than officers appointed by the board of directors, shall hold office at the discretion of the committee or of the officer appointing them.

The finance committee shall have power to suspend the general counsel, the treasurer, the secretary, or the auditor, and to remove anyone in the department of the general counsel, of the treasurer, of the

secretary, or of the auditor. The executive committee shall have power to remove all officers, agents, and employés of the company, except officers elected or appointed by the board of directors, and except officers, agents, and employés in the department of the treasurer, of the secretary, of the general counsel, or of the auditor.

SEC. 2. *Powers and Duties of the President.*—The president shall preside at all meetings of the stockholders, and of the board of directors, and by virtue of his office he shall be a member (but not chairman) of the executive committee and of the finance committee. Subject to the executive committee, he shall have general charge of the business of the company, including manufacturing, mining, and transportation, may sign and execute all authorised bonds, contracts, or other obligations in the name of the company, and with the treasurer or an assistant treasurer may sign all certificates of the shares in the capital stock of the company. He shall do and perform such other duties as from time to time may be assigned to him by the board of directors.

SEC. 3. *Vice-Presidents.*—The board of directors may appoint a vice-president or more than one vice-president. Each vice-president shall have such powers and shall perform such duties as may be assigned to him by the board of directors.

SEC. 4. *The General Counsel.*—The general counsel shall be the chief consulting officer of the company in all legal matters, and, subject to the board of directors and the finance committee, shall have general control of all matters of legal import concerning the company.

SEC. 5. *Powers and Duties of Treasurer.*—The treasurer shall have custody of all the funds and securities of the company which may have come into his hands; when necessary or proper he shall indorse on behalf of the company, for collection, cheques, notes, and other obligations and shall deposit the same to the credit of the company in such bank or banks or depository as the board of directors or the finance committee may designate; he shall sign all receipts and vouchers for payments made to the company; jointly with such other officer as may be designated by the finance committee he shall sign all cheques made by the company, and shall pay out and dispose of the same under the direction of the board or of the finance committee; he shall sign, with the president, or such other person or persons as may be designated for the purpose by the board of directors or the finance committee, all bills of exchange and promissory notes of the company; he may sign with the president or a vice-president, all certificates of shares in the capital stock; whenever required by the board of directors or by the finance committee he shall render a statement of his cash account; he shall enter regularly, in books of the company to be kept by him for the purpose, full and accurate account of all moneys received and paid by him on account of the company; he shall, at all reasonable times, exhibit his books and accounts to any director of the company upon application at the office of the company during business hours; and he shall perform all acts incident to the position of treasurer, subject to the control of the board of directors or of the finance committee. By virtue of his office the treasurer shall be assistant-secretary.

He shall give a bond for the faithful discharge of his duties in such sum as the board of directors or the finance committee may require.

SEC. 6. *Assistant Treasurers.*—The board of directors or the finance committee may appoint an assistant-treasurer or more than one assistant-treasurer. Each assistant-treasurer shall have such powers and shall perform such duties as may be assigned to him by the board of directors or by the finance committee.

SEC. 7. *Powers and Duties of Secretary.*—The secretary shall keep the minutes of all meetings of the board of directors, and the minutes of all meetings of the stockholders, and also (unless otherwise directed by the finance committee) the minutes of all committees in books provided for that purpose; he shall attend to the giving and serving of all notices of the company; he may sign with the president in the name of the company all contracts authorised by the board of directors or by the finance committee, and, when so ordered by the board of directors or the finance committee, he shall affix the seal of the company thereto; he shall have charge of the certificate books, transfer books, and stock ledgers, and such other books and papers as the board of directors or the finance committee may direct, all of which shall, at all reasonable times, be open to the examination of any director, upon application at the office of the company during business hours; and he shall in general perform all the duties incident to the office of secretary, subject to the control of the board of directors and of the finance committee. By virtue of his office the secretary shall be assistant-treasurer.

SEC. 8. *Assistant Secretaries.*—The board of directors or the finance committee may appoint one assistant secretary or more than one assistant secretary. Each assistant secretary shall have such powers and shall perform such duties as may be assigned to him by the board of directors or by the finance committee.

SEC. 9. *Auditor.*—The auditor shall be the principal officer in charge of the accounts of the company, and shall perform such duties as from time to time may be assigned to him by the board of directors or the finance committee.

SEC. 10. *Voting upon Stocks.*—Unless otherwise ordered by the board of directors or by the finance committee, the chairman of the finance committee or the chairman of the executive committee shall have full power and authority in behalf of the company to attend and to act and to vote at any meetings of stockholders of any corporation in which the company may hold stock, and at any such meeting shall possess and may exercise any and all the rights and powers incident to the ownership of such stock and which, as the owner thereof, the company might have possessed and exercised if present. The board of directors or the finance committee, by resolution, from time to time, may confer like powers upon any other person or persons.

Article V.—Capital Stock—Seal.

SEC. 1. *Certificates of Shares.*—The certificates for shares of the capital stock of the company shall be in such form, not inconsistent with the certificate of incorporation, as shall be prepared or be approved by the board of directors. The certificates shall be signed by the president or a vice-president, and also by the treasurer or an assistant treasurer.

All certificates shall be consecutively numbered. The name of the

person owning the shares represented thereby, with the number of such shares and the date of issue, shall be entered on the company's books.

No certificate shall be valid unless it be signed by the president or a vice-president, and by the treasurer or an assistant-treasurer.

All certificates surrendered to the company shall be cancelled, and no new certificates shall be issued until the former certificate for the same number of shares of the same class shall have been surrendered and cancelled.

SEC. 2. *Transfer of Shares.*—Shares in the capital stock of the company shall be transferred only on the books of the company by the holder thereof in person, or by his attorney, upon surrender and cancellation of certificates for a like number of shares.

SEC. 3. *Regulations.*—The board of directors, and the finance committee also, shall have power and authority to make all such rules and regulations as, respectively, they may deem expedient concerning the issue, transfer. and registration of certificates for shares of the capital stock of the company.

The board of directors or the finance committee may appoint a transfer agent and a registrar of transfers, and may require all stock certificates to bear the signature of such transfer agent and of such registrar of transfers.

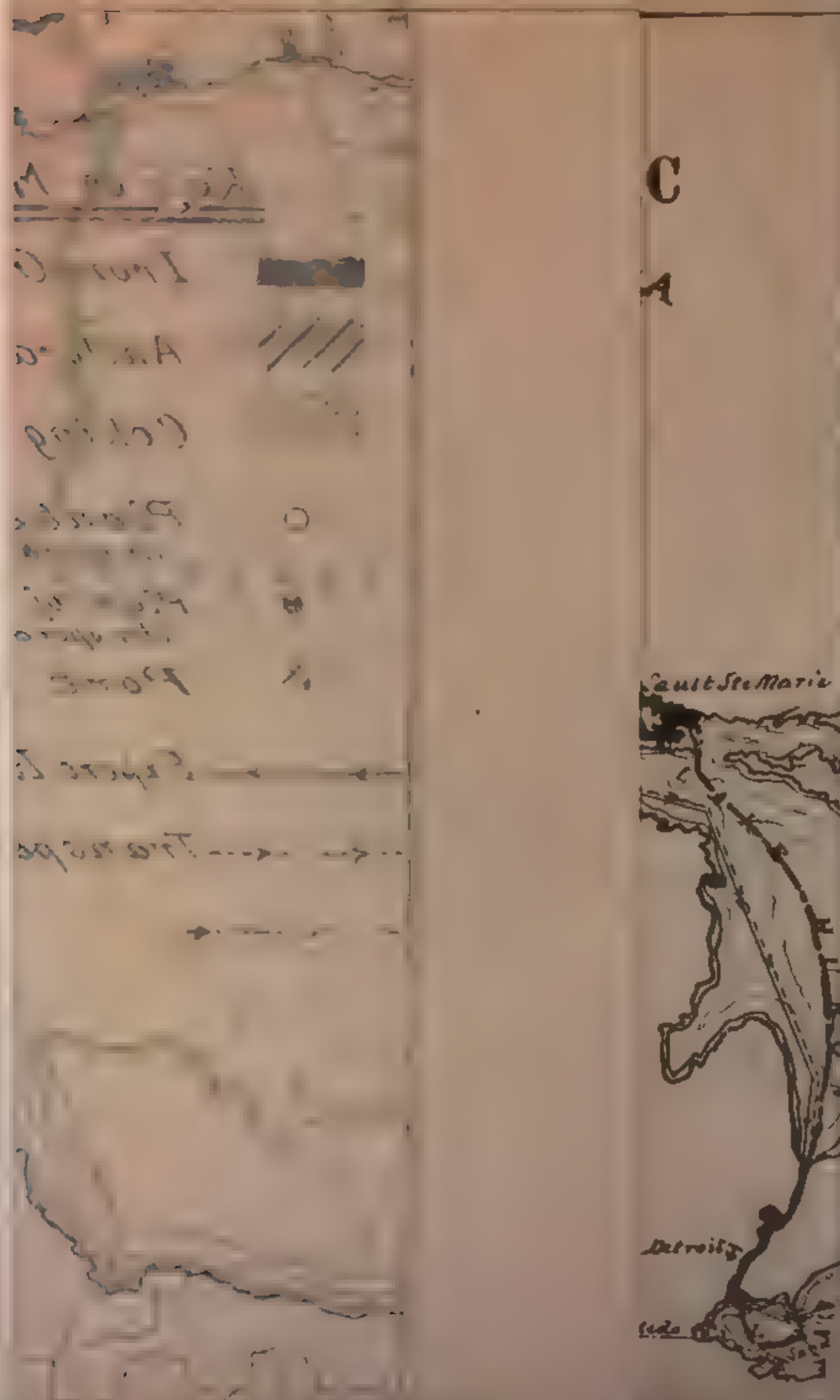
SEC. 4. *Closing of Transfer Books.*—The stock transfer books shall be closed, for the meetings of the stockholders and for the payment of dividends during such periods as from time to time may be fixed by the board of directors or by the finance committee, and during such periods no stock shall be transferable.

SEC. 5. *Dividends.*—The board of directors may declare dividends from the surplus or net profits of the company over and above the amount which from time to time may be fixed by the board as the amount to be reserved as working capital.

The dates for the declaration of dividends upon the preferred stock, and upon the common stock, of the company shall be the days by these by-laws fixed for the regular monthly meetings of the board of directors in the months of April, July, October, and January in each year, on which days the board of directors, in its discretion, shall declare what, if any, dividends shall be declared upon the preferred stock, and the common stock, or either of such stocks.

The dividends on the preferred stock shall be payable quarterly, on the fourth Wednesday next after the several dates of the declaration thereof.

SEC. 6. *Working Capital.*—The directors shall not be required in January in each year, after reserving over and above its capital stock paid in as a working capital for said corporation, such sum, if any, as shall have been fixed by the stockholders, to declare a dividend among its stockholders of the whole of its accumulated profits exceeding the amount so reserved, and pay the same to such stockholders on demand; but the board of directors may fix a sum which may be set aside or reserved, over and above the company's capital paid in, as a working capital for the company, and from time to time they may increase, diminish, and vary the same in their absolute judgment and discretion.



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REPORT MADE

FOR

THE BRITISH IRON TRADE ASSOCIATION

ON THE

Production of Coke and Anthracite Pig-Iron

IN THE UNITED STATES.

By AXEL SAHLIN, Millom, Cumberland.

INTRODUCTION.

MODERN iron making comprises a combination of problems of transportation, engineering and metallurgy, the successful solution of which will result in the production of pig-iron of required composition at a minimum cost.

It is this question of lowest cost and highest quality, as compared with other makers in the same market, that in each case determines the relative importance of the problems confronting the manufacturer. In one case the question of transportation offers the greatest difficulty, in another the composition and form of the raw materials may tax the science and watchfulness of the metallurgist to the utmost, while in others, the skill and ingenuity of the engineer must carry the day.

A report on modern iron making, or blast furnace practice, must, therefore, begin by dealing with the raw materials as they leave mother earth at mine, colliery, or quarry; follow them on their journey to the furnace, and recount the means of handling, transportation and storage. It must also observe the phenomena of their transformation in the furnace, paying particular attention to the means, metallurgical and mechanical, for expediting this transformation; and finally give an account of the disposal and composition of the ultimate products —iron, slag and gases. The human factor in iron making—direction, management and labour, must also be briefly dealt with.

It is the purpose of this Report to give an account of the manner in which the ironmasters and engineers of America, in the

year 1901, are solving these problems of transportation, engineering, and metallurgy in the production of pig-iron smelted with coke and anthracite, as observed during a six weeks' tour in the United States, as a commissioner to the British Iron Trade Association in October and November, 1901, and as studied and learned during 18 years of hard and unremitting work in the service of the iron and steel trade of that country.

The early history of iron making, always interesting and instructive, is admirably told by Mr. James M. Swank, general manager of the American Bessemer Steel Association, the father of statistics of iron and steel, in his excellent book *Iron in all Ages*. I can do no better than refer these interested in the history of iron to this work, and at once go on to deal with the present status of the industry.

Modern iron making in America began when, in 1881, the long-doubted rumour became certainty, that the late Captain William R. Jones and Julian Kennedy, had, by means of high heats and large volume of blast, succeeded in more than doubling the output of the Edgar-Thomson Furnaces, without altering the plant. It became fully established when Andrew Carnegie was the first to recognise and act on the necessity for the successful iron producer to control his own raw material, and it gained international importance when this wonderful man joined to plants and mines the possession of railroads and ships. It is along the lines laid out by these men, and on the foundations largely built by them, that the iron industry of the United States to-day is developing.

In this Report, attention will be given only to iron produced with mineral fuel--coke and anthracite coal. Charcoal iron has been left out of consideration as being of no direct importance to British iron makers.

CHAPTER I.

Geography of Iron.

NATURE has deposited, and man has discovered and opened up, workable deposits of iron ore and fuel in certain often widely separated localities. It has provided certain natural lines of communication, such as seas, lakes and rivers. To these man has added artificial ones, for instance: canals, railroads, aerial cableways, etc. These together constitute the physical geography of iron. The plants which have arisen under the influence of these physical conditions form the political geography of metallurgy.

In America, all the more important productive mines and collieries, and all the prominent iron and steel plants, except that of the Colorado Fuel and Iron Company, of Pueblo, Colorado, are located east of the Mississippi. Within 20 years from now, this statement will probably have to be greatly modified, as considerable deposits of ore and coal in the far west are known to lie waiting for the "westward march of Empire" to reach and develop them.

In tracing the general considerations which influence the locating of iron works, we find four factors which are important in the order named, viz. :—

(1) Fuel supply.
(2) Markets.
(3) Ore supply.
(4) Labour.

(1) *Fuel* is difficult and costly to transport. It is bulky and deteriorates when rehandled or stored. Fuel is also needed, not only for the reduction of ore, but also for the subsequent processes of steel making and manufacturing. It is, therefore, a necessity so to locate plants that they have an abundant and cheap supply of mineral fuel at a convenient distance.

(2) The next factor in importance seems to be the ready access to a *market* where the bulk of the product of the works can be easily and, above all, regularly turned into money. Such access relieves the manufacturer of unlooked-for changes in freight charges, and enables him quickly to take advantage of fluctuations in price, and to deliver promptly the orders confided to him for execution, thereby giving him an unquestioned advantage over a competitor who must make allowance for heavy freight charge, uncertain transportation, and slow transit of his bulky product. It is only seldom that we find an iron plant located away from its market to be successful. If in certain cases success is achieved, this depends on the comparative cheapness of ore, and especially of fuel.

(3) Roughly speaking, two tons of ore, more or less, are required to make a ton of iron. It would, therefore, seem as if it were good policy to locate plants close to the ore supply. Experience teaches us that this is less important than to secure cheap fuel and a handy market. Modern means of shipment, transfer, and storage, make ore transport cheap, and ore does not, as a rule, deteriorate in transit. We therefore find that in all countries, but especially in America, some of the largest and most successful plants are obliged to carry their weightiest raw materials from mines to furnace a distance of a thousand miles or more.

(4) Labour congregates spontaneously at all the great industrial markets. Besides, man will go where he finds his bread and butter. A plant will, therefore, soon create its own supply of labour, and, except in really unhealthy climates, or in localities entirely outside of civilisation, little consideration need be given to the question of labour supply.

The four considerations above named have influenced the locating of the American iron works, and attempts to disregard them have generally been punished by failure or, at best, retarded prosperity.

The map of the eastern part of North America (Frontispiece), shows the location of the principal ore deposits, coking coal regions and blast furnaces at work October 1st, 1901; also the principal lines of transport for ore, coke, and product for export.

CHAPTER II.

Supply and Production of Iron and Manganese Ores.

THE figures given in this chapter are mostly quoted from Mr. John Birkinbine's official report, prepared for the United States Geological Survey, and from Mr. James M. Swank's statistics for 1900. Iron ore occurs in the United States in numerous deposits in the regions of the Appalachian Range, extending from the Canadian line in the north to the middle part of the State of Alabama in the south, a distance of 1,200 miles. In yet mightier deposits, ores are found around the southern and western shores of Lake Superior. West of the Mississippi, large quantities of iron ore are being worked in Central Colorado. Beds of ore of unknown extent, and at present of uncalculable possibilities, are also known to exist in many of the States in the far west and south-west, but production of ore from them is as yet of only local importance.

The most important ore district of to-day is that of Lake Superior, producing during the year 1900, 20,564,238 tons. The States contributing to this enormous tonnage were :—

(1). Michigan, with 9,976,727 tons of almost exclusively red hematite.

(2). Minnesota, with 9,834,399 tons—all red hematite.

(3). Wisconsin, with 746,105 tons—almost wholly red hematite.

The ores of this, the greatest iron district in the world, are found in five so-called ranges. The following table gives the name of these ranges, the tonnage of ore produced from each during 1900, and the total production of each since operations commenced.

In the table, the ranges have been placed in the chronological order in which they were exploited, viz :—

Name of Range.	Year Opened.	Ore Produced, 1900 (Tons).	Total Production up to 1900 (Tons).
Marquette	1856	3,945,068	59,592,793
Menominee	1877	3,680,738	34,015,979
Gogebic	1884	3,104,033	31,216,635
Vermilion	1884	1,675,949	15,191,180
Mesaba	1892	8,158,450	31,400,077
Total		20,564,238 tons.	171,416,664 tons.

It will be noted that, with the exception of the Mesaba Range, the ranges in 1900 took rank in accordance with the dates on which they were opened, and that the Lake Superior region produced 75 per cent. of all the ore consumed in the United States. The production of this marvellous region was doubled within the five years 1895 to 1900. The total amount of ore won from the district from the opening of the mines until December 31st, 1900, amounted to the enormous quantity of 171,418,984 tons.

As to analysis, the ores in the various ranges vary, as follows:—

	Marquette.		Menominee.		Gogebic.		Vermilion.		Mesaba.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Iron	·64	4·0	60·13	38·85	60·64	43·23	66·69	56·99	60·27	51·51
Phosphorus	·52	·012	·72	·012	·138	·028	·13	·035	·088	·027
Silica	38·0	2·8	38·65	2·58	17·76	2·40	7·85	2·04	8·0	2·16
Manganese	3·6	trace	5·29	·08	9·54	·35	·29	·02	1·14	·18
Alumina ...	4·2	·42	3·04	·38	1·97	·25	3·18	·97	2·83	·55
Lime	2·80	trace	2·80	·17	·42	·12	·56	20	1·04	·1
Magnesia ...	3·70	·1	3·84	·29	·40	007	·47	·10	·36	·009
Sulphur ...	·083	003	·223	·0018	·027	·005	trace	none	·052	trace
Loss by Ignition... ...	4·9	·17	9·70	·88	5·85	·86	1·50	·43	12·20	1·84
Moisture ...	10·96	·35	12·33	2·90	14·70	·75	6·71	·52	13·0	7·4

The bulk of Lake Superior ores are particularly suitable for producing a low phosphorus basic open-hearth iron, or a Bessemer iron suitable for rails and structural material.

The freights and distances from the various ranges to Cleveland, Ohio, are about as follows:—

Ranges.	Shipping Port.	Rail Haul (miles).	Rate per Ton—1901.	Lake Transport (miles).	Rate per Ton—1901.
Marquette ...	Marquette	15	1/0½	600	2/11
Menominee ...	Escanaba	40 60	1/8	550	2/6
Gogebic ...	Marquette, Ashland	40	1/8	600	2/11
Vermilion ...	Duluth, 2 Harbours	100	4/2	825	3/4
Mesaba... ...	Duluth, 2 Harbours	75	3/4	825	3/4

The price of a ton of Old Range (lumpy) Lake ore, containing 63 per cent. iron, ·045 per cent. of phosphorus, and 10 per cent. water, f.o.b. Cleveland, Ohio, was at the time of my visit, October, 1901, 17s. 8d.; Mesaba ore (dust fine), containing about 63 per cent. iron, had been sold during 1901 as low as 11s. 6d. per ton. The rail freight from Cleveland or other ports of Lake Erie to Pittsburg during the season 1901, was, including cost of unloading and all harbour dues, 4s. 11d. per ton. The freight from Lake port to the furnace in the Ohio valleys or Wheeling for the same season was 2s. 10½d. From these prices a rebate of 6d. per ton was made if the ore was shipped direct as unloaded, or a reduction of 2½d. if the ore was taken from storage or docks.

The ores in the older ranges are recovered from underground workings. In the newer ranges, Vermilion and Mesaba, the ore is

mostly found in large beds under a surface cover, generally ranging from 7 to 11 ft. in thickness. This cover is removed by steam shovels, and the same powerful instrument, which is made to dig 10 tons of ore at every dip, is then employed to burrow into the ore. This ore is fine and soft, and the cost of mining is nominal. Royalties, where such are charged, range from 5d. to 2s. 6d. per ton, but most of the iron works own their mines outright. The territory around Lake Superior is as yet only imperfectly explored, and new discoveries are made every year. The immensity of the deposits known can be realised from the statement made by Mr. Chas. M. Schwab, that the United States Steel Corporation has now available, in the Lake Superior district, 600,000,000 tons of ore.

The system of transportation for Lake Superior ore will be described in a separate chapter.

The ore deposits of the Appalachian Range have been worked during the past year in the following States, and to the following extent, viz.:—

(1). Pennsylvania, with a production of 877,684 tons, of which about 60 per cent. were magnetites, mostly from the large deposit at Cornwall; the remaining 40 per cent. were divided between brown and red hematites. The Cornwall deposit consists of crystalline magnetic ore embedded in schistose talc, and carrying sulphur as pyrites and copper pyrites. Large films of pure copper are also found embedded in the ore. The deposit has been worked since before the War of the Revolution, when some of the cannon which were used in Washington's armies were cast of iron made from Cornwall ore. The deposit is a homogeneous body filling a crater measuring 1¼ miles in length and about half a mile in width. The depth is unknown. The sides of this crater are formed of thin walls of diabas trapp. The theory for the unique occurrence of this immense deposit is that at some geological date the surface of the country was covered with this mixture of magnetite and schistose talc. An eruption took place, forcing a thin film of trapp through fissures to the surface of the ore deposit, which is located 700 ft. above the present level of the country. Floods later washed away the iron ore until the impervious layer of trapp formed a protection which resisted the action of the water. Later, clay and gravel were packed around the walls of the "beaker," which still, until the present day, have protected those valuable contents of iron ore.

Cornwall (Pa.) Ore (average sample) Analysis:—

	Per cent.
Iron	45·90
Silica	16·90
Alumina	4·25
Lime	3·92
Magnesia	7·21
Phosphorus	·02
Sulphur...	.82
Copper	·56

During previous years the mine has at times been worked to the

extent of nearly 800,000 tons per annum. The cost of placing the ore on railway cars was, a few years ago, given as 7d. per ton.

(2). New York, producing 441,485 tons, of which 78 per cent. were magnetites, largely from Chateaugay and Port Henry; the remainder red and brown hematites and carbonates. There are in New York State very large deposits of lean magnetite, with more or less of impurities. Along the western shore of Lake Champlain, whole mountains of titaniferous ores are found, which, if the day ever comes when we know how to handle a large percentage of titanic acid in the blast furnace, will become of exceedingly great value.

(3). New Jersey produced during 1900, 344,237 tons of almost wholly magnetic ore. It is in the northern part of this State that Thomas A. Edison has carried out his magnificent experiments in magnetic separation, about which more will be said in the following pages.

Following the chains of the Alleghenies into the south, we find a continuation of the ore deposits, which now, however, have changed from magnetite into red and brown hematites. First among the southern States as an ore producer stands—

(1). Alabama, with a production of 2,759,247 tons, of which 72 per cent. were red hematite, and the remainder brown hematite. The principal ore deposit in Alabama is the remarkable Red Mountain vein of fossiliferous ore located near the city of Birmingham. This vein can be traced out cropping along the top of a low hill running from N.N.E. to S.S.W. for a distance of 25 miles. The ore has a uniform thickness of 8 ft. to 8 ft. 3 in., and inclines towards south-east at an angle of about 20 degrees. The ore consists of red hematite, and changes at a depth on the slope of about 400 ft. below the outcropping from silicious soft to calcareous hard ore. The theory is that the ore nearest to the outcropping has been acted upon by the surface water dissolving the carbonate of lime, thus gradually becoming richer and more open. This upper ore is known in the south as "soft red," whereas the deeper-lying is known as "hard red." In addition to this mighty vein, there are scattered over neighbouring parts of Northern Alabama, Western Georgia, Eastern Tennessee, and South-Western Virginia surface pockets containing the brown hematite ore which is so valuable an addition to the mixture of the southern furnaces.

Average analyses obtained of the three ores in use in Alabama are :—

Element.	Hard Red Ore.	Soft Red Ore.	Brown Ore.
Iron	39·70	56·0	50·6
Silica	10·06	12·73	13·30
Alumina	3·93	5·21	4·29
Lime	15·27	·84	None
Manganese	·23	·22	·7
Sulphur	·09	·071	None
Phosphorus	·31	·085	·2

The ore varies considerably in different shafts, and this variation

requires constant watchfulness on the part of the southern furnace managers. One particular firm controls a supply of soft red and hard red ore, which can be mixed to form a self-fluxing burden, The Alabama ores are all used locally.

(2). The second ore-producing State of the south is Virginia, with an output in 1900 of 921,821 tons, almost exclusively brown hematite. The individual mines are scattered over a large area. The deposits are of moderate size and have only local importance.

(3). Third in order we find Tennessee, producing 594,771 tons, of which 55 per cent. were red and 45 per cent. brown hematite.

(4). Georgia and North Carolina together mined 336,186 tons, of which 80 per cent. were brown hematite and the remainder red hematite and magnetite.

In the State of North Carolina is found the vast Cranberry ore field, a mountain ridge consisting of a pure but lean magnetic ore, which, when the problem of concentration is fully solved, and transportation facilities are provided, may become of exceedingly great importance to the southern iron industry for enriching the ore mixtures.

Separated from the other iron-producing States by a distance of more than 1,000 miles, we find the State of Colorado mining ore at the rate of 407,084 tons, mostly brown hematites, the remainder being magnetic ore rich in manganese and silver, for the sake of which latter it is mined. The Colorado iron plant also draws a certain percentage of its ore from Wyoming and New Mexico.

The total production of ore in the United States during 1900 is estimated by Mr. Birkinbine at 27,553,161 tons, with an average value of 2·42 dols., equal to 10s. per ton.

Magnetic Separation.—There are scattered throughout the iron-bearing formations, especially in the Eastern and Rocky Mountain States, great deposits of low-grade magnetic ore, which when crushed, separated, and briquetted forms a very acceptable smelting ore, with from 62 up to 70 per cent. of iron, especially suited for enriching furnace mixtures. It is, therefore, little wonder that the separating business became a popular fad in the late eighties, when electro-magnetic machinery had reached a high grade of development. No less than 34 separating plants were started inside a couple of years. Patents by the hundred for separating and crushing machinery were applied for, granted, and—forgotten. The difficulties were too many, too costly, and too great for most of us novices—I say us, because I myself was attracted by the alluring problems presented, and had my fingers burnt with the rest.

Alone amongst the defeated stood Thomas A. Edison, head and shoulders above the others in brains, genius and resources, and, what is not less important, in pluck, perseverance, and abiding faith in final success. For ten long years he has struggled with the hardest proposition any man ever had set before him. He has spent on it the best energy of his broad mind, and has failed—yes, failed to make and sell at a profit, in competition with Mesaba ore dipped out with a steam shovel, ten tons at a dip, briquetted concentrates made from a rock of which seven tons had to be crushed to a fine-

ness to pass a 53 mesh to the inch sieve, in order to make one ton of concentrates; but he succeeded in making these concentrates technically perfect, in developing the finest crushing and separating machinery that the world has ever seen. He succeeded in overcoming the formidable problems of dust, wear, and separation of weakly magnetic hematite; succeeded in pointing the way for others, and in adding one more to the many debts under which this remarkable man has already placed humanity. Had Edison chosen an easier problem and succeeded, which he undoubtedly would have done, he would never have helped and benefited others, and the industry as a whole, as he now has, and it is to be hoped and wished for that future success, with interest, will repay him for the millions he has unhesitatingly spent in his great experimental plant at Ogden, and for the anxiety and disappointment which this plant undoubtedly at times has caused him.

When seen at his works in West Orange, New Jersey, Mr. Edison said:—"Yes, they had all failed, because they worked on too small a scale to get a product, and because they could not overcome the difficulty of the dust, nor had they sufficiently powerful crushing machinery. At Ogden he had, in addition, met with the difficulty that only two-thirds of the oxide of iron contained in the ore was in the form of magnetite; the rest, being martite, was weakly magnetic and went with the tailings. He now had succeeded in designing bearings which would run for years under two feet thickness of the finest dust." (Demonstrating.) "There was a shaft running 800 revolutions per minute. The journal boxes were ground together and closely fitted. The oil vessel was hermetically closed; the end of the shaft entering the bearing was protected by a collar of clean wool. The little elevator, driven by a motor, delivered a constant flow of the finest quartz dust, pouring it over the top of the bearing; it had been doing so for the last three months, and the journal was now running cool.

"There were his crushing rolls; they had a capacity each of 850 tons of ore per hour. They were faced with chilled iron, and of a diameter sufficient to take in a rock weighing five tons. They were forced against one another under a pressure of 17 tons per square inch, and the springs on which they had been used to rely had been replaced by a rope drive. Each of the many parts of the rope was under a certain constant tension, and all added together were exercising just so much pressure on the intermediate roller." (He must have three rollers in order to reverse the motion.) "He had discarded all belts and line shafting, one of the causes of their early failures. He now used separate dust-proof motors for each machine, and they worked.

"He had also found a way in which he could separate specular hematite, or martite, often found mixed with magnetic ores. These minerals were slightly magnetic, not sufficiently so to be picked up by a magnet, but yet enough to be deflected from a perpendicular course when falling through the field of a large saturated electro-magnet. He took advantage of this by placing below the stream of tailings a sharply-edged diaphragm, which could be adjusted in such a manner that the weakly magnetic particles fell on one side of the

diaphragm, while the purely non-magnetic tailings dropped on the opposite side.

"He was convinced that magnetic separation would succeed as a business, but it must be operated on a large scale, and with a reasonably favourable ore, containing, say, not less than 20 per cent. of magnetic oxide.

"If he had a wide breast from which he could blast the rock, and at the foot of which he could handle it by means of a 10-ton steam shovel, he could drill, blast, shovel and transport the ore a distance of 4,000 ft., delivering it into the crushing rolls at a cost of 5d. per ton. If he had, to begin with, a rock containing 39 per cent. of iron, he could make briquettes analysing 68 per cent. iron at the price of 6s. 2d. per ton. He calculated to crush the ore finely enough to make it pass a sieve having 50 meshes to the lineal inch. Briquettes made from such fine ore by an addition of 60 lbs. of refuse coal tar to a ton of concentrates were easily reduced. In an atmosphere of CO they would be reduced inside of two hours, and in a mixed atmosphere of 2CO and 1CO_2, the time of reduction would not exceed five hours. He had found that the cost of briquetting one ton of concentrates was 2s. 5½d. He mixed the concentrates and coal tar very carefully, and pressed the briquettes very hard. He then passed them over a conveyor, through a drying furnace. The escaping tar gas was brought back to the grate and burned, and by so doing he reduced the amount of coal for drying one ton of briquettes from 90 lbs. to 24 lbs. The briquettes thus made were quite hard, and would stand any amount of rough handling.

"He had just shipped a separating plant for 2,500 tons per day to Dunderland, Norway, and expected to be able to deliver briquetted concentrates containing 68 per cent. of iron in ship at Middlesbrough, at a net cost of 11s. per ton."

Let every friend of England and her iron industry earnestly hope that Mr. Edison is right in this calculation.

Benefited by the experience gained, and by the better machinery now available, new separating plants are again being constructed in America. One of these, belonging to the Pennsylvania Steel Company, is being located at Lebanon, Pa. It is working on the wet method (separation under water), and is designed to deal with the plastic gangue of the Cornwall ore. Another plant is being installed by Mr. Jos. Wharton, at the Hibernia Mines, N.J. This plant will cobble the roughly crushed ore, picking out purely magnetic pieces, while mixed magnetic and non-magnetic portions will be re-crushed and sent on to a fine separator, which will recover the bulk of the remaining magnetite. The separator used in this plant is of the Ball & Norton type.

A third plant is in successful operation at Port Henry, N.Y., where the results are so satisfactory that the capacity of the installation is now being doubled.

Manganiferous Ores.—The manganese ores of the United States may be divided into the following four classes, viz:—

(1). Manganese ore.
(2). Manganiferous iron ore.
(3). Manganiferous silver ore.
(4). Manganiferous zinc ore.

Of the first class, the United States has only a very small supply. The States contributing in the year 1901 were:—

	Tons.
Virginia, product	7,881
Georgia, product	3,447
Arkansas, product	145
Other States......	298
Total ...	11,771 tons.

valued at 8 dols. 52 cents—or 35s. 6d. per ton. From abroad, chiefly from Russia, Brazil, British East Indies and Cuba, the United States imported, in 1900, 256,252 tons of this class of ore.

More important to the iron industry is the second class, the manganiferous iron ore, of which 377,577 tons were mined in Lake Superior district. The value per ton of these ores was estimated at 11s. 5½d.

Manganiferous silver ores raised in Colorado amounted in 1900 to 188,509 tons, value 19s. 10d. per ton.

New Jersey produced in the same year 87,110 tons of manganiferous zinc ore, or residuum, which Mr. Birkinbine estimates to be worth 1s. 8d. per ton.

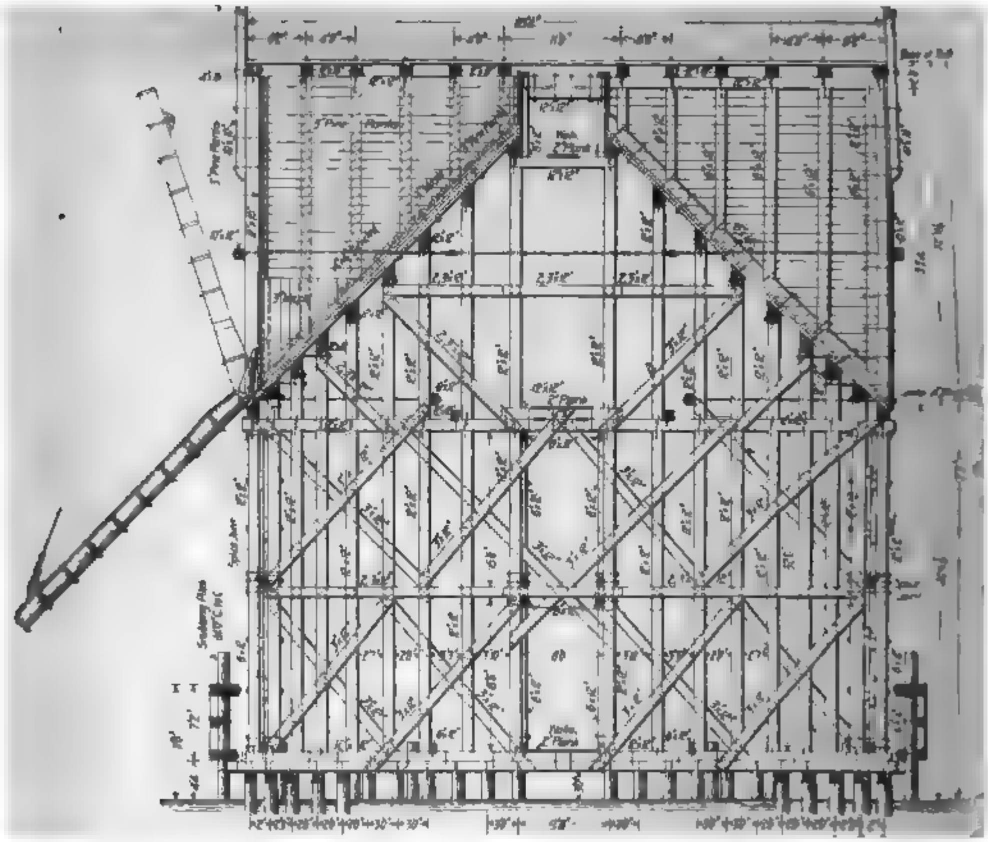
The total quantity of manganiferous ores of all classes mined in the United States during 1900 was, therefore, 664,967 tons, having an average value of 13s. per ton.

The largest producers of manganiferous metals are the Carnegie Steel Company, Pittsburg, Pa., the Cambria Steel Company, Johnstown, Pa., the Pennsylvania Steel Company, Harrisburg, Pa., Mark A. Hannah, Cleveland, O., and others.

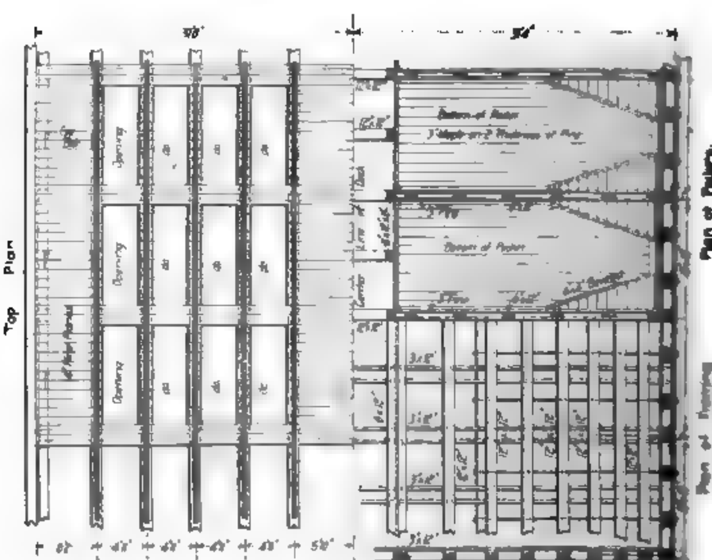
CHAPTER III.

Transportation and Handling of Iron Ore.

IN a previous chapter we have seen how the Lake Superior district, remote from the industrial centres, is producing 75 per cent. of the ore mined in the United States. The remaining 25 per cent. is mostly mined for local consumption. Transportation of this ore is simply a matter of hauling it in cars of the regular railway equipment for a distance of a certain number of miles. The cost of such transportation may be said to average from 0·15d. up to 0·5d. per ton-mile. The lower figure comes nearer the average price, as may be judged from the fact that during 1900, the average charge made by the Pennsylvania Railroad Company for all classes of freight, from explosives and furniture to sand and ore, was 0·47 cents, or 0·24d. per ton-mile.

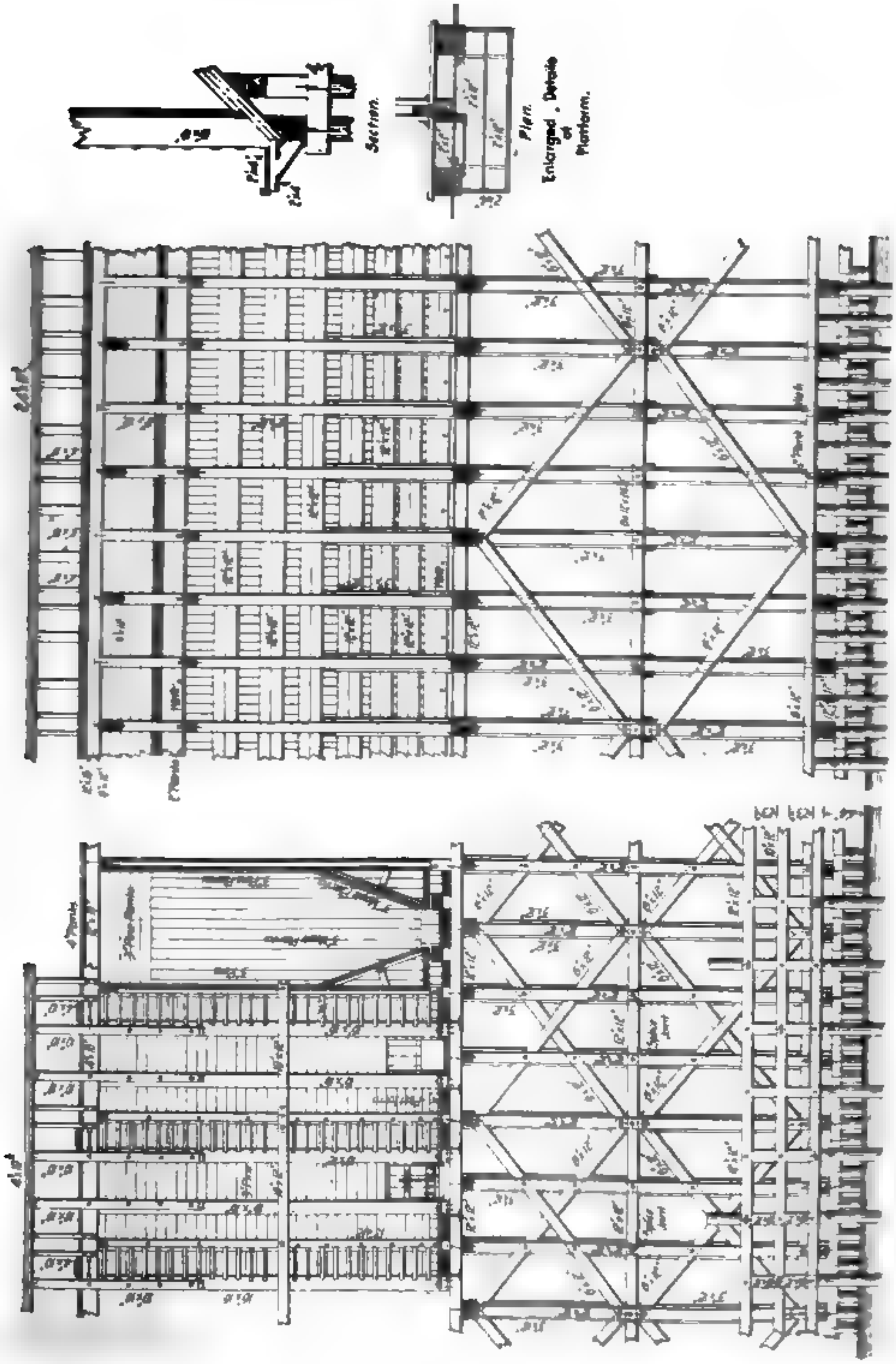


TRANSVERSE SECTION



PART PLAN SHOWING POCKETS, POCKET FRAMING AND TRACK CONSTRUCTION.

FIG. 1.—LAKE SUPERIOR ORE DOCK.



LONGITUDINAL SECTION.

SIDE ELEVATION SHOWING SECTION OF POCKET.

FIG. 2.—LAKE SUPERIOR ORE DOCK.

The manner in which the Americans have succeeded in transporting the product of the Lake Superior mines over the distance separating them from the industrial centres at a cost enabling the iron manufacturers to compete, and not only undersell manufacturers using local ores, but also to export their product at a profit to foreign lands across the ocean, is one of the great achievements of American engineering bearing on the production of iron.

The 20,000,000 tons of Lake Superior ore are, during the shipping season, hauled from the different ranges to the most convenient shipping ports; the names of these ports and the approximate distance from the ranges are given in Chapter II. For the transport are utilised the ordinary American 30-ton hopper-bottom cars, which, however, now are being rapidly replaced by 50-ton steel cars.

The ore trains are run directly on to docks or piers, in which are built self-emptying pockets for storing the ore. The bottom doors of the cars are then opened, and the ore is transferred by gravity into the pockets.

As we in England have our "Lake Superior district" in Scandinavia and Spain, where shipping facilities of better order must be provided, I here briefly describe one of the larger ore docks—that of the Great Northern Railway, in the harbour of West Superior.

The dock has a capacity of 40,000 tons of ore. Its construction is clearly shown by the accompanying illustrations, Figs. 1 and 2.

It measures 1,500 ft. in length, 63 ft. 10 in. in width, and 73 ft. 10 in. in height from the water level to the top of the rail. The pier, or, as it is called, dock, consists of two rows of pockets each having a capacity of 250 tons of ore. This dock was built in the spring of 1900, and was placed in operation in the early summer of that year. It is an excellent example of timber work design.

A steamer of from 5,000 to 7,500 tons may be loaded from the pockets of the dock inside of a couple of hours, the trimming being done by raising or lowering the ore spouts as required.

The typical lake steamer, shown by Fig. 3 is a unique modern construction, admirably evolved to meet the by leaps and bounds increasing traffic of the great inland seas. The depth of water available is only 20 ft., and even at this draft, the steamers often run aground, when persistent winds have driven the water towards one end of the oblong lakes. The shipping season is short, closing early in winter. Labour is scarce and dear. Therefore, the motto, "Time is money," applies more directly and forcibly to shipping on the Great Lakes than to most branches of human industry.

The boats are flat bottomed, with strong longitudinal and transverse keelsons and double skin. The sides are perpendicular and strongly braced. The steel deck is supported by a continuous line of central stanchions, and is perforated by as large a number of hatches as the length of the ship permits. These hatches measure uniformly 8 ft. fore and aft, and are spaced 24 ft. centre to centre, in order to correspond with the discharging machinery. The length athwart ship depends on the beam, but is generally 32 ft. The triple expansion engines, with their two Scotch boilers, are housed

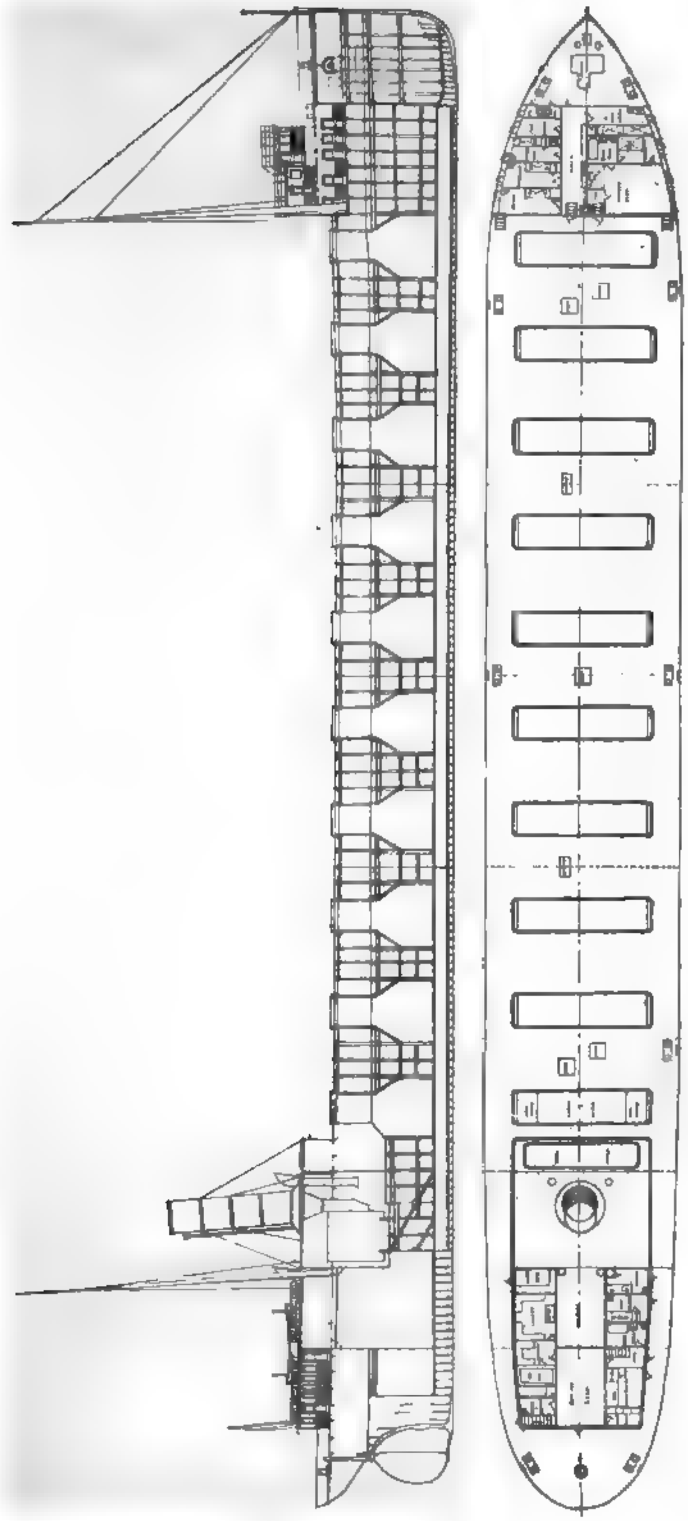


FIG. 3.—LAKE STEAMER (LONGITUDINAL AND CROSS SECTIONS).

close to the stern. The pilot house, with officers' and crew's quarters, is well forward of the foremast. The rigging, consisting of one, two or three pole masts, is purely, though questionably, ornamental. With its flush deck, without a vestige of run or sheer, its blunt stem, and unsightly hatch combings, the ship gives the impression of a pontoon, but, nevertheless, this type is proving entirely seaworthy and practical.

All the work on the lake boats is done by capstans and windlasses. The steering apparatus is worked by steam. The speed of the boats probably averages from 9 to 12 knots. But it is especially in port that their wonderful time-saving capacity is demonstrated. At the Upper Lake docks, the ore descends in continuous streams

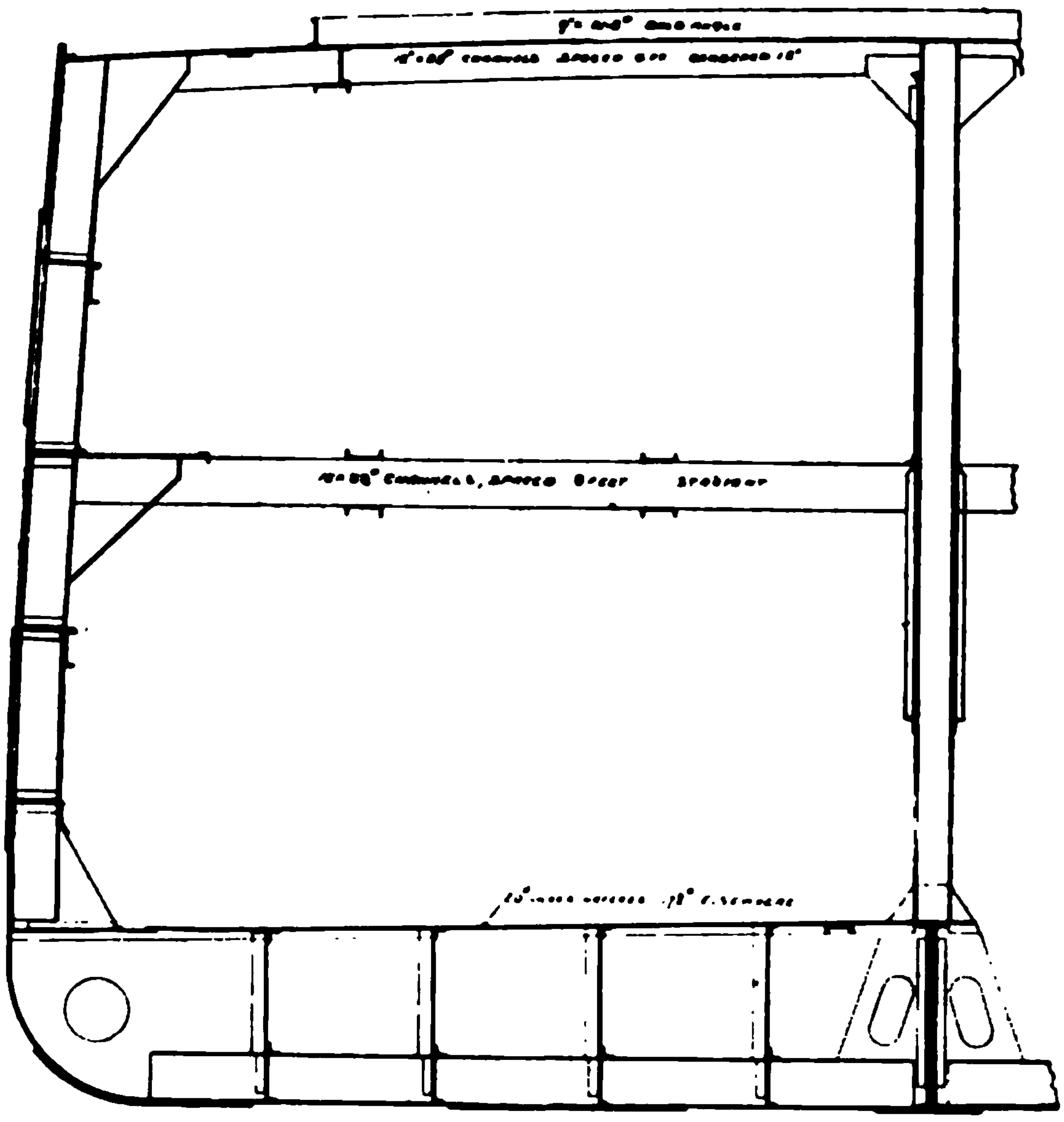


FIG. 4.—CROSS SECTION OF LAKE STEAMER.

through all of the ten, twelve, or fourteen hatches, loading the ship in a remarkably short space of time. There is a record that a 5,000-ton boat was once loaded in 20 minutes, but, generally, from two to four hours are required, as the cargo must be trimmed, and as the ship must be moved from one set of pockets to another. As soon as the loading line touches the water, the ship is backed out from the dock, the hatches are screwed down, and the return trip is begun, without steam ever having been blown off. It is not unusual that the return trip up the lakes can be made in eight days. About 67 per cent. of the steamers go up the lakes in ballast; the remainder are mostly carrying cargoes of coal, for which the freight charge during 1900 was 1s. $5\frac{1}{2}$d. per ton to Upper Lake ports, and 2s 6d. per ton to Milwaukee or Chicago. The steamers are often made to tow so-called consorts, which are simply barges fitted with small auxiliary engines and winches. The carrying capacity of the consort is often greater than that of the steamer itself.

FIG. 5.—BATTERY OF TWELVE "FAST PLANTS" AT THE PORT OF CLEVELAND, O.

A spool-shaped model, known as a "whale back," was greatly in favour a few years ago, but has now been abandoned, as it did not prove the claim of cheap construction and operating cost made by its promoters. The whale backs are, however, recognised as entirely seaworthy.

The size of the ore boats has, during the last few years, been gradually increased, until the climax was reached in the *John W. Gates*, measuring 498 ft. in length, 52 ft. in width, and 30 ft. in moulded depth. This steamer, on a draft of 20 ft., will carry 8,339 tons. This year a reaction has set in, most shippers now preferring 5,000-ton boats. This size is convenient to load with two kinds of ore, and delivers quantities easily handled at the furnace. The dimensions of such a boat would be 346 ft. keel, 48 ft. beam, and 28 ft. moulded depth. The triple expansion engines measure 22-in. high pressure cylinder, 35 in. intermediate, and 58-in. low pressure cylinder, with a stroke of 40 in. A steam pressure of 180 lbs. would be carried in two Scotch boilers, having a diameter of 13 ft. 2 in., with a length of 11½ ft. The Howden forced draught system is generally in use.

On arrival in the Lower Lake port, the steamers are placed under a battery of unloading machines.

The credit for the evolution of this class of machinery belongs to Alex. E. Brown, vice-president of the Brown Hoisting Machinery Company at Cleveland, Ohio, who, in 1880, first designed and put in operation his so-called bridge tramways, and who afterwards has continued to devote himself to the improvement and invention of new machinery, with the result that during the year 1899, 95 per cent. of all the ore and coal tonnage of the Great Lakes was handled by Brown's unloading machines. There are two principal types of these machines, viz.:—

(1.) The fast plant for unloading from ship directly to railway cars.

(2.) The bridge tramway for unloading from ship into storage. The latter type can, however, also be used as a fast plant for direct trans-shipment.

The Brown fast plant, as shown by Fig. 5, consists of a track, with trolley suspended from a steel frame on wheels, and covering, as the case may be, two, three, four, or up to seven railway tracks. The frame also supports steam or electric hoisting machinery. The trolley carries an automatic dumping bucket of one ton capacity, which is lowered into the ship through the hatch, unhooked from the hoisting machine, and filled with ore by hand shovels, while a previously filled bucket is hooked on to the hoist and raised, moved along the suspended track, dumped with mathematical precision over the car, and returned to the hold of the vessel. Each machine, as a rule, works three buckets, and keeps employed seven shovellers for each hatch. To avoid collision with the masts and rigging of the ship, the overhanging part of the suspended trolley track is hinged, and can be drawn up into vertical position. The round trip is made in 45 seconds. The velocities reached are:—

For hoisting, 300 ft. per minute.
For travel, 1,200 ft. per minute.

FIG. 6.—12 STANDARD BRIDGE TRAMWAYS ERECTED FOR PENNSYLVANIA CO. (M. A. HANNA DOCKS, CLEVELAND) FOR HANDLING ORE. LENGTH OF SPAN, 192 FT. 9 IN.; CANTILEVER, 104 FT.; APRON, 38 FT.

The feature of the Brown machine is that the bucket tips automatically on reaching a certain point of the track, and also that the vertical motion automatically changes into horizontal, and becomes greatly accelerated. All details are also executed with the greatest care and ingenuity.

During my visit, I timed a battery of 12 fast plants at work cleaning out the last remnants of a cargo. During 20 minutes, the plant of 12 machines averaged 13 one-ton buckets per minute, though the shovellers were unable to keep pace with the machines. Had there been more ore in the hold at the time, the speed would have been even greater. The cost of a Brown fast plant, with a capacity of about 40 tons per hour, varies from £2,000 to £2,500.

For storage of ore another form of the Brown machine is used, shown by Fig. 6, the so-called bridge tramway. In this machine the track is longer—in some cases and for special purposes, as long as 563 ft. The hoisting machinery and principle are otherwise the same as those of the fast plant. The bridge tramway runs on wheels, and can be moved along the pier either by hand power or by machinery. The cost of a bridge tramway is from £2,500 upwards, according to the length and capacity. Between 400 and 500 Brown unloading machines are now in operation on the Great Lakes.

The Brown machines are generally worked in sets of four, that is, one steam boiler serves four machines. To handle 160 tons of ore per hour from the hold of the boat on to car or storage place, therefore, requires five men, viz., four operators and one fireman. One ton of coal will suffice to handle 1,000 tons of ore. If electricity is used for motive power, the services of the fireman are dispensed with, and the cranes can be economically operated as single machines.

Recently, the Hulett automatic unloading machine has been introduced in some of the larger lake ports. The machines, as erected for the Carnegie Steel Company at their docks at Conneaut, O., were built by the Webster, Camp & Lane Company, of Akron, Ohio, and are illustrated by Fig. 7. The machine consists of a structural steel frame mounted on 16 wheels, running on four 100-lb. T rails. The span of the frame is about 70 ft., with a cantilever of 30 ft. The top of the main girders of the frame forms a track on which a trolley, carrying a ponderous walking beam, travels. On the rear end of this beam is resting a steam hydraulic intensifier or accumulator. On the opposite forward end is trunnioned a depending steel leg. The steel leg is guided near the top by equalising beams, so that it always remains in a vertical position. At the bottom end of the leg is attached a two-part clam-shell bucket of 10 tons capacity. This bucket is opened and closed by a hydraulic cylinder mounted on the depending leg. It is rotated in a complete circle by another hydraulic cylinder placed in the same leg. The bucket when open has a length of 21 ft., and, having an eccentric motion, it has a reach under the deck of the boat of 13 ft. from the centre of the hatch in any direction. The power for the machine is furnished by a 150-h.p. loco. type boiler, carrying a steam pressure of 175 lbs. The hydraulic plant is worked under

a pressure of 1,000 lbs. per square in. The walking beam is moved up and down by a hydraulic cylinder by means of a cable attach-

FIG. 7.—HULETT AUTOMATIC UNLOADER.

ment. The trolley carrying the walking beam is moved in and out over the vessel by another hydraulic cylinder.

The operator working the machine has his place in the depending

leg immediately above the bucket, and descends into the hold of the boat with the machine. All the motions of rotating, opening, and closing the bucket, and of tilting and racking the walking beam are controlled by this operator. In addition to this machinery, the unloader is provided with a winding engine which moves it up and down the dock from one hatch of the boat to another. It also operates a car mounted on the lower flange of the main girder, which receives the ore from the 10-ton bucket, and delivers it into the railroad cars on either of the four tracks running under the main frame of the machine.

At Conneaut, there are four of these machines, each having its separate track for the supply of empty cars. To operate the unloader are required :—

		£	s.	d.	
1 Operator	at	18	15	0	per month.
1 Pump man	„	15	12	6	„
1 Car operator	„	15	12	6	„
1 Fireman	„	15	12	6	„

With this crew, an average quantity of 200 tons per machine per hour can be unloaded, and record runs of 300 tons per hour per machine have frequently been made. As the grab bucket works too roughly to come in contact with the frame of the ship, it has been found advisable to remove with the Hulett unloader only 75 per cent. of the cargo. The remaining 25 per cent. is handled by Brown fast plants in the manner described above. The cost of unloading a ton of ore with the Hulett machine is ½d. The cost of handling the 25 per cent. by means of the hoisting machines and hand shovels may be estimated at about 8d. to 9d. per ton. The average cost of unloading and placing on wagons a cargo of ore with the best machinery now available is therefore, according to data given by the Webster, Camp & Lane Company's engineer, 3d. per ton. When considering this price, the great saving effected by the ability to handle a cargo of from 6,000 to 7,000 tons in one day must be borne in mind.

During my visit to Conneaut I saw a steamer arriving in the morning with a cargo of 6,700 tons of ore leave the same evening in ballast for the Upper Lakes.

Railway Transport.—The American so-called "ore roads" have within the last decade done their best to handle in an economical manner the enormous and growing mineral traffic which passes over their lines near the industrial centres. Leading amongst them in this respect stands the Pittsburg, Bessemer and Lake Erie Road, now controlled by the United States Steel Corporation. This road forms one of the most important links in the machinery for the modern manufacture of iron, and I therefore feel justified in giving it and its equipment a special description.

The line extends from the harbour of Conneaut, O., located within a couple of miles of the point where the boundary between Pennsylvania and Ohio reaches Lake Erie, to North Bessemer Station on the Union Railroad of the Carnegie Company. The distance between the terminals is 131 miles, the road traversing a hilly and difficult

country. The steepest grade on the line is 40 ft. to the mile, the sharpest curve has 650 ft. radius. The road, which is single tracked, is laid with 100-lb. rails 6 in. high, with flanges 6 in. wide; the rails are 30 and 33 ft. in length, and are supported by 14 oak sleepers to each 30-ft. rail. The sleepers measure 8 ft. 6 in. in length, 7 in. thick, and not less than 8 in. in width. The permanent way is ballasted with blast furnace slag. The cost of the line is calculated at about £7,200 per mile, bridges and stations not included.

The port of Conneaut, which is controlled by the Railway Company, is well protected against the winds of the stormy lake. For unloading it is equipped with the following machinery, viz.:—

4 Hulett automatic unloaders.
12 Fast plants—Brown system.
10 Bridge tramways—Brown system.
1 Coal tipple.

From this port are despatched during the season, from 12 to 14 ore trains per day. The heaviest weight of train has been 2,404 tons, the net weight of the ore amounting to 1,849 tons. The percentage of dead weight hauled (tare) was, therefore, 23·08 per cent. The average weight of ore carried by each train during the season is, however, only 1,024 tons, but the percentage of dead weight is in each case the same. In one month (August, 1901) there were handled over the road 729,280 tons of freight, out of which 550,404 consisted of ore. The charge made to outside customers for taking one ton of ore out of the hold of the vessel, transporting it to Pittsburg, and delivering it on the furnace trestle was, during the year 1901, 4s. 11d., from which price must be deducted 10d. for dock handling and 7½d. per ton for shifting charge in Pittsburg, making the net price charged to outsiders for the 131 miles, 3s. 5½d. per ton. As to the actual cost of ore transportation, this figure has been given me in confidence, and cannot, therefore, be repeated, but I feel justified in quoting from a statement made in print by the *Railroad Gazette* giving profit per train-mile on various ore roads, viz. :—

		$	£	s.	d.
Profit per train-mile—	Pittsburg, Bessemer and Lake Erie Railroad	5·38	1	2	5
,, ,,	Chesapeake and Ohio Railroad	1·32	0	5	6
,, ,,	New York Central and Hudson River Railroad	1·84	0	7	8
,, ,,	Erie Railroad	1·47	0	6	1½

These figures are fully borne out by the marvellously low costs given me by unquestioned authorities.

Equipment.—The reader will recognise the noteworthy fact that the dead weight of an ore train on this road amounts to 23·08 per cent. of the freight carried. This result has been attained by the introduction of the 50-ton steel car. These cars are built of three general types represented by Figs. 8, 9 and 10, viz. :—

(1) The pressed steel car, manufactured under the patents of Mr. Schoen, by the Pressed Steel Car Company, with head-quarters in Pittsburg. It was in 1897 that this company turned out their first car. The practicability of the new design was then gravely doubted, even by railway men. At this writing the company are turning out

50-ton steel cars at the rate of 118 per day, consuming for the same from 1,500 to 2,000 tons of material, and have in the four short years

FIG. 8.—50-TON ORE CAR, BUILT BY THE PRESSED STEEL CAR COMPANY, PITTSBURG, PA.

they have been in business manufactured over 50,000 cars. The 50-ton pressed steel ore car measures—

Length over couplers	22 ft.
Width overall . .	8 ft.
Height above rail ...	9 ft. 6 in.
Angles of floor ...	45 degrees.
Capacity .	927 cub. ft.
Weight .	29,000 lbs.

FIG. 9.—50 TON ORE GONDOLA, BUILT BY THE CAMBRIA STEEL COMPANY, JOHNSTOWN, PA. (PENNSYLVANIA RAILROAD).

The car is built of plates in no instance less than ¼-in. thick. If painted once every three years, the prevailing impression is that the life of the car will be at least 45 years, as compared with 15 years representing the average life of the wooden car. The pressed steel car on the P. B. & L. E. Road is equipped with Tower automatic couplers, Westinghouse air brakes, pressed steel diamond trucks, with open-hearth steel axles having journals 5½ in. diameter × 10 in. in length, and special chilled 33-in. wheels, each weighing 650 lbs. The bearings are of nickel bronze. The cost of a 50-ton ore car as above described is about $1,050, or £216.

The draw-gear is of the Westinghouse friction type for freight cars. The cars are permitted to travel over the railway lines carrying an overweight of 10 per cent.

(2.) The structural steel car, as manufactured by the American Car and Foundry Company, the Cambria Steel Company (Pennsylvania Railroad Company), and others. In general equipment the structural car is very similar to the pressed steel car. Fig. 9 shows a 50-ton ore gondola of steel, built by the Cambria Steel Company.

The body of this car weighs 19,149 lbs., the trucks 14,575 lbs.; total weight of car 33,724 lbs.

(3.) The Sterlingworth car, shown by Fig. 10, is built of rolled shapes, principally channels and flats. For this car the makers claim that it is stronger and lighter than any car of the same capacity now being manufactured. The car weighs 28,500 lbs.

The advantages gained by the introduction of large capacity cars are, briefly stated:—

(1) The reduction of 50 per cent. in dead weight of train, as compared with carrying capacity.
(2) Reduced number of cars required.
(3) Reduced friction and atmospheric resistance.
(4) Shorter train length.
(5) Greater traffic capacity of the main line, and especially of sidings and terminals.
(6) Reduced switching service.
(7) Reduced payments for car mileage and inspection.
(8) Reduced cost of repairs.
(9) Reduction in number of parts pertaining to each car.
(10) Greater durability and longer life of cars.

A hopper car of 100,000 lbs. net, 107,180 lbs. gross capacity built according to the three systems above described, weighs:—

	lbs.
Pressed Steel Car Company (Pennsylvania R.R. pattern)	29,000
The Cambria Steel Company (flat-bottom gondola) ...	33,724
The Sterlingworth Car	28,500

It is difficult to give an opinion of the advantages of each of the above three types. Suffice it to say, that all have proven themselves entirely practicable, that the difference in percentage of dead weight to load is practically none, and that they all are economical in unloading.

On the Pittsburg, Bessemer and Lake Erie Road, three styles of locomotives are employed, viz:—

Type "A"—"The Biggest of All"—Fig. 11.
Type "B"—"Consolidation" type—Fig. 12.

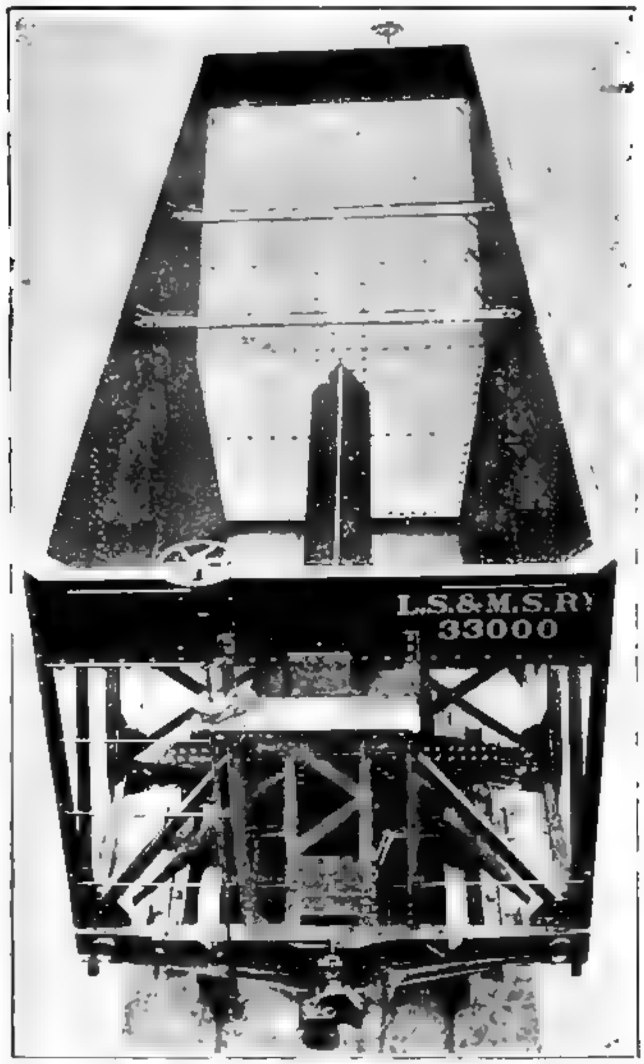


FIG. 10.—STRUCTURAL STEEL HOPPER CAR (END VIEW) BUILT BY THE AMERICAN CAR AND FOUNDRY CO., OF DETROIT.

Type "C"—"Mogul" type—Fig. 13.

The first is used only for moving the freight trains up the heavy grades from Conneaut to the receiving station at Albion. The locomotives of Class "B," are those generally used for moving the trains from Albion to the southern terminal at North Bessemer.

Fig. 11.—Class "A"—Largest Locomotive Hitherto Made—
"The Biggest of All" Type.

Fig. 12.—Class "B"—"Consolidation" Type.

Fig. 13.—Class "C"—"Mogul" Type.
Figs. 11, 12 and 13.—Standard Locomotives in Use on Pittsburg, Bessemer and Lake Erie Railroad.

Class "C" are used for pushers and yard work. The table below gives the respective principal dimensions of the three classes, viz:—

	Class "A."	Class "B."	Class "C."
Gauge	4 ft. 8½ in.	4 ft. 8½ in.	4 ft. 8½ in.
Diameter of cylinders	24 in.	22 in.	20 in.
Stroke	32 in.	28 in.	26 in.
Number of drivers	8	8	6
Diameter of drivers	54 in.	54 in.	56 in.
Number of bogie wheels ...	2	2	2
Wheel base	15 ft. 7 in.	15 ft. 4 in.	14 ft.
Wheel base total	24 ft. 4 in.	23 ft. 8 in.	22 ft. 5 in.
Base of engine and tender ...	58 ft.	?	?
Weight on drivers	225,200 lbs.	159,200 lbs.	129,000 lbs.
Total weight without tender ...	250,300 „	173,200 „	146,750 „
Weight of tender with coal and water	134,000 „	70,000 „	80,000 „
Grand total weight	384,300 „	243,200 „	226,750 „
Tank capacity	7,500 galls.	5,000 galls.	4,000 galls.
Heating surface	3,805 sq. ft.	?	?

Between them, these three classes of locomotives represent as powerful and economical an equipment of freight movers as can be found on any railroad now in existence.

Traffic Arrangement.—Trains are made up at Conneaut, each composed of 35 cars. This load is hauled up the steep gradients to the yards at Albion Station, four miles distant, by one heavy locomotive of Class "A." At Albion, the cars are redistributed, each train consisting of 38 cars being drawn by a locomotive of Class "B." A single engine suffices to pull this train for a distance of 92 out of the 131 miles, but for the remaining 39 miles of heavy up-grades, a pusher engine is attached behind the train. The trip of 131 train-miles, however, only requires 148 locomotive-miles, as the same pusher is aiding a number of trains up the grade at which it is stationed. The time generally consumed for the journey is 13 to 14 hours.

The crew of an ore train consists of:—

		s.	d.		
1 Engineer	at	16	8	per	day,
1 Fireman	„	10	10	„	„
1 Conductor	„	12	6	„	„
1 Flagman	„	8	4	„	„
1 Brakesman	„	7	11	„	„

When on duty in the yard, the men receive 50 per cent. over-pay for time in excess of 12 hours per day. On the line, 100 miles' run constitutes one day's work.

Twenty-five per cent of the ore trains return loaded with coal for shipment to the Upper Lake ports; the remaining 75 per cent.

are sent back empty. In addition to the heavy ore traffic, three passenger trains are run daily in each direction.

For efficiency and economical traffic arrangements this road easily takes the lead of all mineral railways in the world, and it unquestionably owes its existence and organisation to the far-sightedness and genius of Andrew Carnegie.

The other ore carriers, though crippled by not controlling so large a share of the ore-carrying business, and by having to cater to other lines of trade, and to a greater amount of passenger traffic, are all shaping on the same lines, and using the same expedients for cheapening and promoting their mineral traffic.

CHAPTER IV.

Mineral Blast Furnace Fuel and Flux.

THERE were mined in the United States during the year 1900 189,744,565 tons of bituminous coal, and of anthracite coal 51,221,353 tons, making a total of 240,659,918 tons. Besides, there were used as fuel large quantities of mineral oil and natural gas.

For blast furnaces and foundries were made 20,533,348 tons of coke, and, in addition, three-quarters of a million tons, more or less, of anthracite coal were used in the blast furnaces of the east.

The best coking coal is found in Western Pennsylvania and West Virginia. Coke, though not so good, is also largely made in Virginia, Tennessee, and especially in Alabama. Anthracite is mined exclusively in Central Pennsylvania around the head waters of the Schuylkill, Lehigh and Lackawanna Rivers, and east of the Susquehanna Valley. The principal coking coal regions are indicated on map (Frontispiece).

Coke burns fast, and is, therefore, a preferable fuel for iron making. Anthracite, on the other hand, is purer. It burns so slowly, however, that it is nowadays seldom used, except with an admixture of coke.

Half, and by far the best half, of the blast furnace coke is produced in the Connellsville region, a mining field located about 50 miles east of Pittsburg, whence fuel is shipped to furnaces as far west as Chicago. The production of Connellsville coke in 1900 was 9,076,900 long tons. Almost equal to Connellsville coke is that of the Pocahontas region in West Virginia, whence fuel is supplied to furnaces in Eastern Pennsylvania, Maryland, Virginia, West Virginia and Ohio. The southern coke is higher in ash and sulphur, and softer than those described above. The greater part of it is made

in Alabama, principally in the district around Birmingham. Below are given representative analyses of—

	Anthracite.	Connellsville Coke.	Alabama Coke from	
			Washed Coal.	Unwashed Coal.
Carbon	86·00	85·00	83·00	82·00
Ash	7·00	10·00	14·00	15·00
Sulphur	·68	·95	·96	1·63
Phosphorus	·003	·010	—	—

Coke is also produced from the coal mined on the slopes of the Allegheny Mountains in Western Pennsylvania. When made in beehive or retort ovens, this coke is soft and generally high in sulphur. The advent of the by-product retort ovens has, however, made it possible, by deposition of carbon from the dissociated hydrocarbons, to produce coke from this "mountain coal," which, for instance, at the Cambria Works, is indiscriminately used in the blast furnace, together with Connellsville coke, volume for volume. The mountain coke is somewhat higher in carbon than that from Connellsville. At the Maryland Steel Works of Sparrows Point, Maryland, the Lebanon Furnaces, and at the Lackawanna Company's new plant at Buffalo, large installations of by-product ovens are now being built for the purpose of coking Pennsylvania mountain coal. The types of ovens used are almost exclusively Otto-Hoffman and Semet-Solvay. The coal is crushed and washed at the mines, and is then shipped to the coke ovens, which are located close to the iron works. In this way, the serious deterioration of the fuel by transport and re-handling is avoided. It is also recognised that the by-product oven produces from 12 to 15 per cent. more coke from a ton of coal than is done in the older and still universally employed ovens of the beehive and retort type.

In America, coke is mostly shipped from the ovens to the works in covered wagons to protect it from moisture. It is not unusual to find coke containing less than ½ per cent. of moisture, and more than 2 per cent. of water will call forth a protest and deduction from the weight to be paid for. A modern type of coke wagon, built by the Pressed Steel Car Company, is shown by Fig. 14.

The supply of coal in America is practically inexhaustible. It is true that some specialists estimate that the Connellsville basin may, at the recent rate of production, be exhausted in about half a century, but large tracts in Western Pennsylvania, in West Virginia and Alabama, not to mention other mining districts, are underlaid by two or more workable seams of coal, which will require centuries to exhaust; besides, coal is from year to year discovered at points in the (from the iron maker's point of view) unexplored States to the west of the Mississippi.

As furnaces are now being built in the Upper Lake region, preparations are being made for shipping coke and coal to the same by the returning ore steamers. Coal is also carried up the lakes for

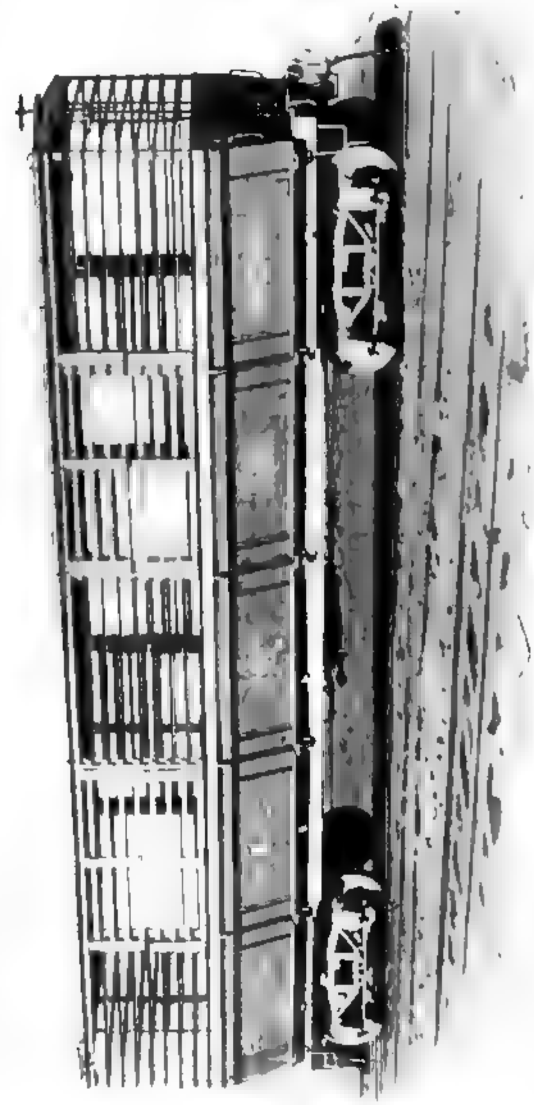


FIG. 14. PRESSED STEEL COKE CAR, BUILT BY THE PRESSED STEEL CAR COMPANY, PITTSBURG, PA.

steaming purposes for lake craft, mines and manufacturing plants. The coals, like those mined in Wales, suffer by breakage, and are, therefore, loaded by means of a car tipple, views of which effective machine are shown in Figs. 15 and 16.

FIG. 15.—THE BROWN COAL TIPPLE AND TRANSFER CRANES, SHOWING CAR IN POSITION, COVER RAISED, COAL BEING LOWERED INTO HOLD OF SHIPS

The tipple consists of a hinged platform on which the loaded car can be clamped by means of hooks worked by hydraulic or electric power. When the loaded car is thus secured, a cover containing six hoppers, with trap doors for bottoms, descends over the top of the car. Platform, car and cover are now overturned, until the coals gently slide out of the car into the hoppers of the cover, which at the same time enter into six corresponding transfer boxes placed on a car standing alongside of the dumping machine. When the filled hoppers touch the bottom of the transfer boxes, they open automatically, and as the cover with the now empty car and platform is withdrawn, the coal is left in the transfer boxes practically without drop, shock or abrasion.

The car with the filled boxes is moved by an endless rope to a position under the loading cranes, and another car carrying empty transfer boxes is placed at the car tipple.

The coal car is in the meantime returned into its original position, the cover is raised, and the hooks are lifted. The car is now empty and free to move.

The tipple is built at such a level that the approaches from both ends rapidly slope away from the machine. On the receiving side, a narrow-gauge track is placed inside of the standard gauge one, ending in a pit at the foot of the slope. Into this pit descends a push-car, or so-called "ground-hog," operated by a winding engine and wire rope. On the far side of the pit, the tracks of the receiving yard rise sufficiently to let the loaded coal cars run by gravity past the pit. When, now, a car has passed over the ground hog, this is pulled out of the pit, carrying the coal car ahead of it, until the car mounts the platform, and pushes the empty car standing there ahead of it on to the down grade track on the delivery side of the tipple, whence it reaches the yard where the trains of empties are being made up.

As the transfer boxes are being filled, they are handled by two or more loading cranes, consisting of a girder supported by a frame on wheels running along the quay. The girder can be moved in and out at right angles to the dock, so as to overhang and command the hatches of the ship. To the girder is attached the hoisting trolley, which lifts the boxes, runs them out over the ship, and lowers them through the hatches until they strike against the bottom of the ship or the cargo placed in it, when their bottoms automatically open, leaving the coal in the hold.

For coal suffering by breakage, this method is of great value, for it is both expeditious and cheap. Ten men working one tipple and two transfer cranes will transfer in one day of 10 hours 4,000 tons of coal out of cars into the hold of the ship. The machine described and illustrated was invented by Mr. Alex. E. Brown. A number of them have been built by the Brown Hoisting Machinery Company, of Cleveland, Ohio. One machine with its two cranes is said to cost about £12,000, erected on the lake front ready for operation.

Crude coal oil is far more frequently used in America in connection with blast furnace work, than is the case in Great Britain. If

the furnace slips, and the slag notch or iron tap, or tuyeres are filled and lost, the American manager immediately resorts to the blow-pipe. A tank containing crude oil is either attached to the upper part of the furnace, or oil is being forced by a pump to enter the blow-pipe at a certain pressure. The blow-pipe consists of a piece of 2-in. pipe, connected with the hot blast main of the furnace. In the centre, inside of the same, is run a ½-in. pipe connected with the oil supply. By rightly regulating the flow of hot blast and oil, a flame of the most intense temperature is produced at the end of the pipes, which will rapidly cut through the mixture of slag and iron closing the aperture to be opened. The blow-pipe is a time saver, and a friend of the blast furnaceman in trouble.

Fluxing Materials.—The American ores are, almost without exception, silicious. Basic flux must, therefore, be added. Limestone of good quality is abundant in most of the manufacturing districts. Dolomite is also to be found in numerous deposits. The American blast furnace manager as a rule employs magnesia, together with lime, to form slag. It enables him to carry a more basic slag, as the melting-point of a three-base silicate is lower than that of a two-base one. By this practice a better control of sulphur is also claimed. The fluxing stone is always crushed to about 2 in. mesh. Gyrating crushers of the Gates type are largely used at the quarries. Fine crushing causes the flux to present a larger surface to the action of the fuel, and hastens the expulsion of carbonic acid which, if carried to the lower zones of the stack, would be apt to retard the work of the furnace.

The only instance known to me where no flux is used is at a certain furnace plant in Alabama, where a silicious and basic ore are blended in such proportions as to form a self-fluxing mixture.

When speaking of flux, it may be proper to state that several American furnace managers unite in the assertion that it is necessary for regular furnace working to produce not less than 8 cwts. of slag for each ton of iron made. Unless this quantity is obtained, the furnace runs "dry," and its working becomes irregular. For that reason, it is claimed that no material advantage is gained when the ore mixture in the furnace runs above 57 per cent. The pure Lake ores high in iron are therefore mixed with ores of lower grade, so that the necessary amount of slag can be made.

CHAPTER V.

Location of the Furnace Plants.

A [illegible] at the map (Frontispiece) will show the principal iron-mining [illegible] indicated by ■, and the furnace plants, indicated by [illegible] and ● for two or more furnaces working. Only the [illegible] on October 1st, 1901, are marked on this map. [illegible] are marked thus—XXXX; anthracite fields thus – [illegible] shows clearly how a supply of local fuel and [illegible] are characteristic of the plants in certain localities.

The furnaces of the Lake front will be found grouped around the great cities and railway centres—Chicago, Cleveland, and Buffalo —from which the product can be readily distributed, where labour is plentiful, and where ore and coke can be assembled at cheap through rates, and with a minimum of rehandling. Those furnaces which a few years ago were built at the upper end of the Great Lakes are not in operation. They are too far from fuel and market to work profitably. The proximity of the ore does not sufficiently improve their position to enable them to compete with plants in a more central situation.

Leaving the Lake shore, the eye naturally rests on the dense group of furnaces located around Youngtown, O., in the Mahoning and Shenango Valleys. The majority of these furnaces are independent or "merchant furnaces," selling a product of pig-iron. This location is chosen because, while it is yet near the Lake ports, Pittsburg, the principal market for the iron, and Connellsville, the source of the coke supply, are appreciably nearer than they are to the furnaces on the Lake shore.

The cluster of furnaces around Wheeling and in the Hanging Rock district has approached still nearer to its fuel, West Virginia and Connellsville, and to its market, Pittsburg and Ohio and the Mississippi River Valley.

Pittsburg, the iron capital, is also located on the same great highway—the navigable rivers which traverse the continent. Taking advantage of the excellent mineral fuel supply, as well as of natural gas and oil close at hand, it has created its own busy market, and is now stretching its tentacles of trade and making itself felt to the remotest parts of the world wherever iron or steel is used or bought. Enterprise, skill and experience, ample capital, and diversity of manufactures have given Pittsburg an advantage and lead as an iron-making centre which, within the next generation, no other place will contest.

At the scattered furnaces to the east of the Alleghenies, new influences are brought to bear. Foreign ore is imported, together with Lake Superior ore, and both are used as admixture to the local ores, or do at times wholly take their place. Fuel is drawn from Connellsville, from the Pocahantas region of West Virginia, and from the anthracite field of Eastern Pennsylvania. The home market of the densely populated country studded with the manufacturing cities, the convenient highways of the neighbouring sea, together with abundant and intelligent labour are the considerations which justify a permanent iron industry in this part of the country, though the cost of iron at the eastern furnaces always stands higher than in Pittsburg and in the west. In this district are also located numerous furnace plants, which probably never will be relighted, on account of their distance from the fuel supply. The small deposits of local ore which caused the furnaces to be constructed do not give them sufficient advantage to off-set the long transport of fuel.

In the south, the remarkable combination of fuel, ore and flux, all to be found within a radius of two or three miles, creates especially favourable conditions, which makes it possible to seek at a distance

markets which the surrounding country is not yet sufficiently developed to supply. As this promising section of the country grows and develops, it will gradually consume a greater and greater portion of its locally produced iron, and will thereby give the iron industry increased stability, prosperity and development.

All the furnaces of the eastern part of the United States can be referred to one or other of the groups, the conditions of which have been outlined above. Isolated from them all by a distance of more than 1,000 miles stands the group of Colorado furnaces at Pueblo. These have a monopoly on their own raw materials, fuel, ores and flux, and are also privileged in their own market in the far west and on the Pacific slope.

A general tendency is noticed to locate new enterprises either along the Lake front, preferably near the large railway centres, or in the valleys of the Ohio and its tributaries. The practice also prevails to reduce cost of manufacture by combining iron and steel plants, and by converting the metal taken direct in liquid form from the furnace. The advantage obtained by this method is considered sufficient to justify great expenditure. At the works of the Carnegie Steel Company, at Homestead, and of Messrs. Jones & Laughlin, in Pittsburg, the furnace plants are located on the northern shore of the Monongahela River. Ponderous bridges have been thrown across the waterway, over which the hot metal trains cross from the blast furnaces to the steel works. The bridges, which are of steel, are, of course, thoroughly protected from damage by firebrick linings, should the molten metal break through the ladles or a wreck occur.

CHAPTER VI.

Blast Furnace Plants.

ON October 1st, 1901, the following number of coke and anthracite furnaces were running in the United States, given by States and districts, as reported to the American Iron and Steel Association, viz.:—

Location of furnaces.	No. in blast. Oct. 1st, 1901.	
New York	4	Total for New York ... 4
New Jersey	4	
Spiegel	3	
		" " New Jersey... 7
Pennsylvania:		
Lehigh Valley	14	
Spiegel	1	
Schuylkill Valley	10	
Upper Susquehanna ...	1	
Lower "	6	
Spiegel	1	
Lebanon Valley	1	
Pittsburg District	30	
Spiegel	1	
Shenango Valley	14	

Location of furnaces.	No. in blast. Oct. 1st 1901.		
Pennsylvania (*continued*):			
Western Pennsylvania	13		
Spiegel	1		
		Total for Pennsylvania	93
Maryland	4	„ „ Maryland	4
Wheeling District	8	„ „ West Virginia	8
Ohio:			
Mahoning Valley	13		
Central and Northern	13		
Hanging Rock	9		
		„ „ Ohio	35
Illinois	16		
Spiegel	1		
		„ „ Illinois	17
Minnesota	0		
Wisconsin	3	„ „ Wisconsin	3
Missouri	0		
Colorado	1		
Spiegel	1		
		„ „ Colorado	2
The South:			
Virginia	14		
Kentucky	4		
Alabama	22		
Tennessee	8		
Georgia	0		
North Carolina	0	„ „ The South	48
Total	221	Total	221

The total output from these furnaces per week is estimated at 300,538 tons; at the same time 89 furnaces, considered in good working order, and with an estimated output of 54,823 tons, were idle.

More than 50 per cent. of the blast furnace plants in operation in 1892 have since then been blown out and abandoned never again to be rekindled. Their places have been taken by a smaller number of giant furnaces of the modern type, equipped regardless of cost, but with the strictest eye to economy and efficiency of operation. The cost of one modern American furnace was, in no case where I could ascertain it, given as less than £160,000, but in other cases there have been spent on one furnace stack and equipment £300,000. This sum, of course, includes all the necessary plant for taking care of slag, transporting molten metal to the steel works, storing ore, and doing minor repairs around the furnace. The considerations which have dictated the location of modern furnaces have previously been touched upon. To those mentioned above might be added a fifth factor, viz., water supply. A modern blast furnace of the type now built in America requires from three to five million gallons of water per 24 hours, and in order not to ruin the furnace equipment this water should be soft and as free as possible from impurities, especially from acids and carbonate of lime.

The nearness to fuel and market has attracted to Pittsburg the grandest aggregation of iron smelting furnaces ever constructed.

Furnace Stacks.—Plate II., Figs. 1—12, shows the inside lines of

twelve furnaces selected as representative. The following general rules are observed in the determination of these lines:—

(1) *Height.*—It is conceded that the higher the furnace is the more economically it will work. The limitations are determined by:—

(*a*) Blast pressure available.
(*b*) Mechanical strength of the fuel.
(*c*) Reducibility of the ore.

Thirty pounds per sq. in. is considered sufficient maximum blast pressure for a furnace 105 ft. high, the average working pressure being from 16 to 22 lbs. Connellsville coke will support a column of burden 95 ft. high, Alabama coke a column 70 ft. high, while anthracite has not hitherto been tested in columns higher than 65 ft.—all above the tuyere line. Where large quantities of Mesaba and other easily-reducible ores are used, it has been considered advisable to reduce the height of the modern furnace from 105 to 90 ft., or even 80 ft.

(2) *Hearth Diameter.*—The diameter of the hearth is determined—

(*a*) By the amount of blast available.
(*b*) By the percentage of silicon which the iron is intended to contain.

Furnaces producing foundry iron are being built narrower in the hearth. The largest hearth diameter yet employed is 16 ft., but the large Buffalo furnaces of the Lackawanna Steel Company, now building, are to be given a hearth diameter of 17 ft. Furnaces using from 50,000 to 60,000 atmospheric cubic ft. of blast per minute usually have a hearth diameter of 14 to 15 ft.; 40,000 to 45,000 cubic ft. of blast corresponds to a hearth diameter of from 12 to 13 ft.; 34,000 to 38,000 cubic ft. justify an 11 ft. hearth; and from 25,000 to 30.000 cubic ft., a 10 ft. to 10 ft. 6 in. hearth. These figures are taken from actual practice.

Tuyeres are invariably placed in one plane from 7 ft. to 10 ft. above the level of the tap hole. The general rule for determining the number of tuyeres is, approximately, one tuyere for every foot of hearth diameter. The diameter of tuyeres varies from 7 in. to 4½ in., and is often changed to obtain different working of the furnace. A smaller tuyere will drive the blast farther into the furnace; a larger tuyere will pass a greater volume of blast up along the bosh walls. The slag notch is placed about 3 ft. to 3 ft. 6 in. below the tuyere plane. A well for iron, 12 in. to 15 in. in depth, is formed below the level of the tapping hole. This well will constantly stand filled with liquid metal, which protects the hearth brick, and tends to minimise sudden changes of composition of the iron.

(3) *Bosh.*—The bosh area is often made from 2·25 to 2·50 times larger than the hearth area. The height of bosh in modern furnaces varies from 8 ft. to 15 ft. The more easily reducible and the finer the ore, the lower the bosh is built. The angle of the bosh walls, which in the past has been considered a matter of great importance, is left entirely without consideration. The American blast furnace-man reasons that the object of the bosh is to prevent the column

of unreduced stock from dropping in front of the tuyeres. If the bosh is too high, unreduced material will come down below the top of the same, in which case a wedging action sets in, and the furnace is likely to hang. If, again, the bosh is too low, the zone of fusion may come above the bosh walls and the column will descend irregularly. It has been proven that, as a rule, the zone of fusion is located far lower in the furnace, and nearer to the tuyeres, than has in the past been supposed to be the case. If easily reduced ores, and ample volume of blast are to be had, 8 ft. above the tuyeres has, therefore, proven an entirely sufficient height for the bosh. An example of such a low bosh is shown by Fig. 8, Plate II. This furnace has just been blown out after a most successful campaign. Fig. 9, Plate II., shows the most recent furnace built by the same company. It was explained to me that the height of the bosh had been increased, as it had been demonstrated that a very low bosh added to the necessary blast pressure. It is, therefore, the most recent practice to build the furnace boshes from 12 to 15 ft. high above the tuyere lines, the lower figure being for finer, the higher for coarser ore.

(4) *Shaft.*—The shaft of the furnace is generally built as one straight frustrum. It is claimed that with this construction, the most uniform descent of the stock will take place. The incline of the walls of the furnace stack vary from 3 to 100 to 4 to 100 out of the perpendicular It is generally conceded that a narrow top increases the coke economy. The considerations which limit the diameter are (1) the velocity of upgoing gases, which, if made too great, would cause excessive quantities of dust to be carried out of the furnace, and (2) the practicability of handling a fairly large charge on the bell. As a rule the stock line varies from 17 ft. to 12 ft. 6 in. The bells are invariably of the ordinary Parry type. Diameter of bell is from 3 ft. 6 in. to 5 ft. less than that of the stock line. An average is probably: Diameter of bell 4 ft. less than diameter of stock line. With rapid driving, furnace managers incline to the use of several gas out-takes joining outside the furnace into one or two downcomers. It is claimed that if only one downcomer is provided, the flow of gas rushing towards the same will, when meeting the descending stock, carry away sufficient ore and coke dust to change the working of the furnace on the side nearest the downcomer.

(5) *Construction.*—The foundation of the furnace is made to rest on rock or equally reliable material. If necessary, deep piling is resorted to. The foundation under the columns is generally built in concrete capped by red brick in cement. A large ring of heavy cast-iron plates or girders is placed under the furnace columns. The columns vary in number, from 6 to 10, and are carried up to the top of the bosh or above this line. The lintel plate on top of the columns is either built of structural steel or of heavy steel castings. On top of the same rests the plate shell of the furnace, which in a modern furnace is made with double riveted vertical and horizontal seams, the bottom course of plates being about $\frac{5}{8}$ in. to $\frac{3}{4}$ in. thick; the upper courses are gradually reduced to $\frac{3}{8}$ in.

The hopper is bolted to the furnace shell or to solid brackets attached to the same. Heavy brackets also carry the supports for the hoist and top gear.

The hearth is protected by heavy cast-iron plates from 4 in. to 6 in. thick, or by steel jackets reaching down from 2 ft. 6 in. to 4 ft. below the hearth level. In some cases, the entire hearth is built in a box of 1¼ in. steel plate resting on a number of parallel joists of cast iron or steel. The tuyeres are carried in a belt of cast iron or steel collars, all joints between the collars, coolers and tuyeres being metallic and machined. The bosh is protected by rows of bronze cooling plates, between which are placed strong horizontal steel bands for holding the brickwork. From 8 to 11 rows of cooling plates are generally placed in the furnace. Many of the smaller furnaces are equipped with a jacket of steel plate sprayed on the outside to protect the thin brick lining. The hearth is built of brick blocks; it measures generally 6 ft. in depth. The blocks are either tapered, so as to form inverted spherical segments, or made with hooks attaching each brick to its neighbour. The hearth well, bosh and shaft are generally built of bricks 2½ in. to 3 in. thick, 4½ in. to 6 in. wide, and 9 in. and 13½ in. long. The composition of a generally liked furnace brick is shown by the following analysis:—

	Per cent.
Silica	52·62
Alumina	40·61
Sesquioxide of iron...	3·69
Lime	·68
Magnesia	·75

For the top part of the furnace shaft, special bricks are made, either of potter's clay, or of very finely ground fire-clay, the theory being that the furnace gases will penetrate into the interstices in a permeable brick depositing carbon, which in due time will cause the brick to crumble. Special care is taken to make the joints in the brickwork as thin as possible. For mortar, nothing but liquid fine clay dipped up with ladles is permitted. Great care is taken to get all bricks of uniform thickness. The thickness of the walls ranges, for the hearth, from 30 in. to 48 in.; for the tuyere belts from 21 in. to 27 in.; for bosh walls, when fitted with cooling plates, from 27 in. to 30 in., when fitted with spraying jackets, from 9 in. to 13½ in.; for the shaft walls from 24 in. to 36 in. To prevent abrasion from the falling stock, bricks of white cast iron are often built into the walls of the upper portion of the shaft alternately with the fire-brick.

The bustle pipe is placed outside of the columns, having a separate brick-lined branch for each tuyere. No general hot blast valve is provided, the blast being cut off at the stoves.

An automatic relief valve about 15 in. in diameter placed on top of the bustle pipe will drop and set the furnace in communication with the outside air, as soon as blast is taken off; thereby an accumulation of explosive gases in the bustle pipe is prevented. Around the top are often provided a number of large explosion doors which relieve the

shocks due to sudden slips or to instantaneous reduction of the fine ore. These explosion doors are by no means a matter of form, but are often brought into play on the high power American furnaces.

Julian Kennedy, the well-known engineer, of Pittsburg, has recently designed a furnace for the Iroquois Iron Company, near Chicago, with an entirely closed top, capable of withstanding a pressure of 35 lbs. per sq. in. It is Mr. Kennedy's opinion that explosions are caused by the possibility for the gases to escape, whereas if sufficient pressure were opposed to the exit, the explosions would be reduced to a gradual discharge through the downcomer. It must be borne in mind, however, that the pressure will communicate itself to the tuyere belt and bosh, which also must be made sufficiently strong to resist the increased pressure. Mr. Kennedy's blast furnace charging apparatus is shown in Fig. 17.

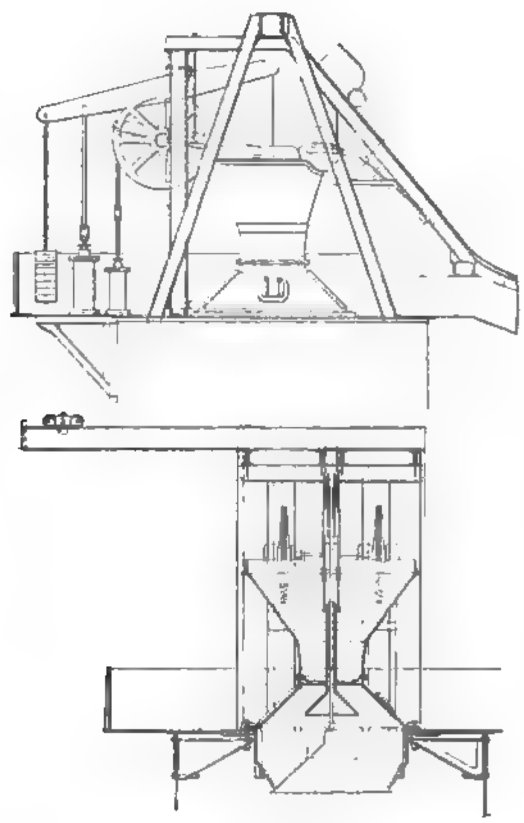


FIG. 17.—KENNEDY'S BLAST FURNACE CHARGING APPARATUS.

The tuyeres, coolers and cooling plates are amongst the unique features of the American blast furnaces. Without tuyeres which can fairly successfully resist the intense temperature and the incessant wash of slag and iron, modern blast furnace practice, in the American

sense, would be impossible. To stop one of these large furnaces once or twice a day to exchange tuyeres would be fatal to its working. Therefore, great attention is paid to the finish and composition of these pieces of machinery. They are cast out of what is practically pure copper. Several makers guarantee to furnish tuyeres with not less than 99½ per cent. of copper. An analysis of an American tuyere made by the Best Manufacturing Company, of Pittsburg, Pa., gives :—

Copper	...	99·71 per cent.
Tin	...	·23 „
Lead	...	trace.
Zinc	...	trace.

The method of casting these tuyeres is a trade secret. Probably each maker has his own method and formula. Silicon-copper and phosphor-copper probably play an important *rôle* in making the castings solid. Before leaving the shop, the tuyeres are machined, tapped and furnished with a pipe for leading the incoming water to the nose of the tuyere. They are then tested under a hydraulic pressure of 100 lbs. per sq. in.

The accepted practice is to place the tuyeres to reach 9 in. into the furnace. The cooler is flush with the in-wall. Cooling plates are also placed flush with the inside of the bosh, or at most 3 in. to 6 in. behind the face of the wall.

Here a warning against too much cooling of a furnace bosh is in order. Only with very strong blast is it advisable to carry the cooling plates to the top of the bosh. Too much cooling will tend to create deposits of fine carbon on the bosh walls. But if powerful blast of high temperature is used, cooling by water is the only successful method of maintaining the lines of the lower part of the furnace.

Stoves.—The types of stoves adopted for the American furnaces are :—

(1.) Julian Kennedy's Cowper stove, with round openings, hexagon brick, and one-sided combustion chamber.

(2.) Julian Kennedy's Cowper stove, with central combustion chamber, hexagon brick and round holes.

(3.) McClure & Amsler's modification of the Massicks Crooke three-pass stove with central combustion chamber and chimney valve on top.

(4.) Hartman's two-chamber stoves.

It is recognised that it is not only the number of square feet of heating surface which determines the value of a stove, but that also the condition of this heating surface, the mass of brickwork backing it, and its accessibility for cleaning and repair, make for the efficiency of the stove. The stove foundations are built with the same care as those of the furnace stacks, and are carried down to a solid supporting stratum. Four stoves are allotted to each furnace stack. The size of the stoves is usually 22 ft. diameter by 100 ft. to 105 ft. high. The casings are built of heavy steel plates, double riveted, the bottom courses which receive the mountings measuring ⅝ in. or ½ in. in thickness. The upper courses are reduced to ½ in. or $\frac{7}{16}$ in. The dome is given a spherical radius equal to the diameter of the stove. Opposite the

skew back of the brick lining for the dome, the shell is reinforced by two outside steel bands riveted to the shell.

The gas valves are of the Spearman-Kennedy patent type, pulling away from the opening in the stove, which is closed by a brick-lined sliding door. By this arrangement no air can leak through the gas valve when the stove is on blast. The gas mains are placed above ground, and are provided with numerous dust-catchers, cleaning and explosion doors, to facilitate the periodical removal of dust.

The hot blast valves are of the mushroom pattern, with hollow bronze stems and water circulation. They rest on hollow, removable bronze seats of Berg's patent type. The hot blast valves are generally worked by means of steam or pneumatic pressure. The diameter of hot blast valves varies from 28 in. to 36 in. for a large modern furnace.

The chimney valve for the Cowper-Kennedy stoves is of the mushroom pattern, with water-cooled seat and often water-cooled valve. For the modified Massicks & Crooke stove, a slide valve with air cooling is provided on top of the dome of the stove at the base of the superimposed chimney. The diameter of chimney valves varies from 42 in. to 54 in. They are ordinarily worked by means of steam or pneumatic pressure. It is considered preferable that each stove should have its own smoke stack, but in many cases an underground or elevated smoke flue connects with one stack common for the stoves of one or two furnaces. This stack is generally built about twice as high as the stoves which it is serving. Draught of $\frac{3}{4}$ in. water column is deemed entirely sufficient. The stacks are built of steel plates, and are lined with fire-brick.

The cold blast valves are of slide valve pattern, from 26 in. to 36 in. in diameter.

Boilers.—In regard to boilers, preference is divided, but the blast furnace experts all agree that, unless the feed water is so bad as to prevent their use, water-tube boilers are the best type for blast furnace work. In order to create the high blast pressure required for the modern blast furnace, high pressure steam, from 120 to 160 lbs. per sq. in., must be generated. As pressure increases, the thickness of plate in a flue or cylinder boiler will of necessity become so great that the heating surface afforded by it rapidly loses in value, while, at the same time, the cost of the boiler rapidly increases.

When, in describing boilers, the term "horse power" is used, it should be understood that, in American practice, 1 boiler horse power is the capacity of evaporating per hour 30 lbs. of water from 212° Fahr. into steam of 80 lbs. pressure. For doing this work, the various makers of water-tube boilers allow a heating surface of from 10 to 12 sq. ft. The types of water-tube boilers principally employed are :—

(1) *Cahall.*—This boiler, as shown by Fig. 18, consists of one short upright cylinder forming a mud drum. The bottom sheet of the same is dished. The top or tube sheet is flat, and stayed to the sides and head of the cylinder. A similar cylinder turned upside down forms the steam drum. The tube sheets of the two are con-

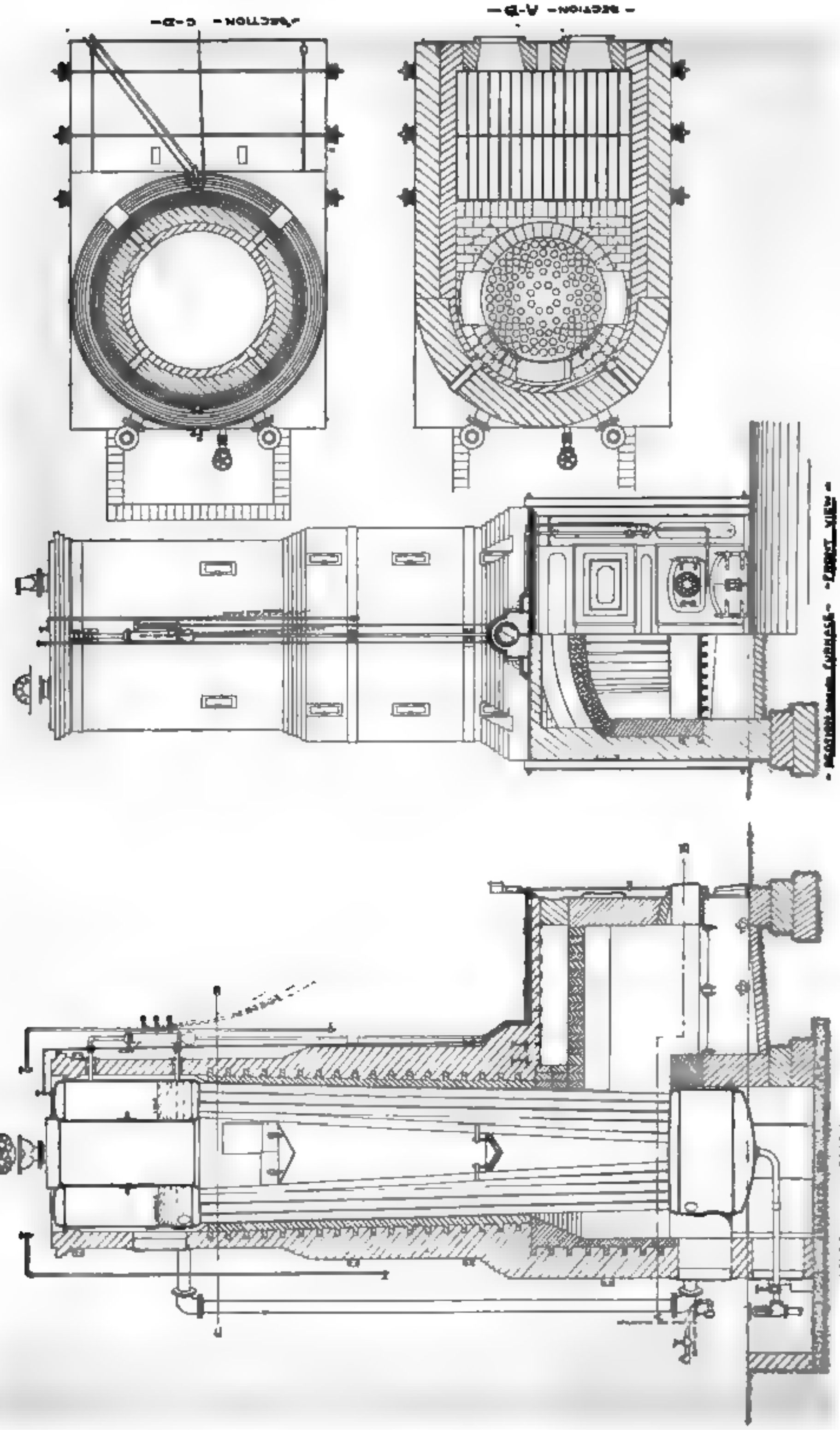


FIG. 18.—250 H.P. CAHALL UPRIGHT WATER TUBE BOILER, BUILT BY THE AULTMAN-TAYLOR MACHINERY CO., MANSFIELD, O.

nected by a number of vertical water tubes. The whole structure is enclosed in a chimney-like brick setting, at one side of which stands

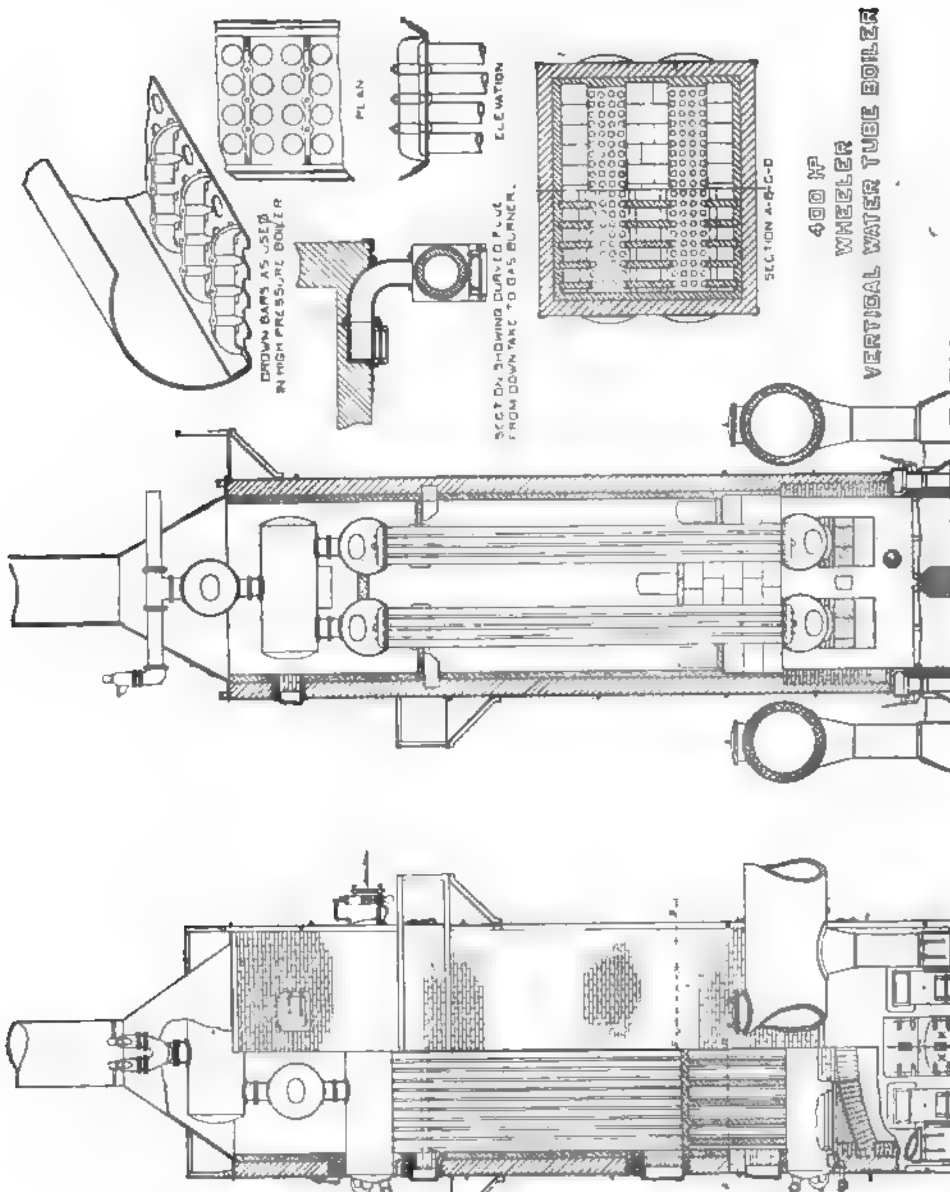


FIG. 19.—400-H. P. WHEELER VERTICAL WATER TUBE BOILER, BUILT BY W. W. SHILLING, SHARON, PA.

the liberally-proportioned combustion chamber. An outside pipe of large dimensions, connecting the mud drum with the steam drum,

provides for the return flow of water. Through the centre of the steam drum, a flue connects with the superimposed smoke stack, and provides an escape for the gases. Two deflecting plates in the central space between the tubes and alternate projections from the surrounding walls, force the gases, which enter around the bottom part of the tubes, in and out between these, until they finally escape through the central opening in the steam drum. It is easy to understand that the evaporation in the vertical tubes must be very violent, and that a strong flow of water and steam will ascend into the steam drum. The water again returns through the outside pipe into the mud drum, thus setting up a very rapid circulation. The Cahall boiler is accessible, a good steamer, and occupies very little room. It is a favourite with the Carnegie Steel Company, who, at this writing, have hundreds of these boilers in operation.

(2) *Wheeler Vertical Tube Boiler.*—As shown by Fig. 19, this boiler consists of two horizontal cylindrical mud drums, with flattened tops, the flat tops being supported by crown bars, something after the manner of the crown sheet of a locomotive fire-box. The steam drums are similar to the mud drums turned upside down. The two are connected by vertical tubes expanded into the flat side of each. The top drums are connected by necks to two horizontal cylindrical steam drums, and these again by similar necks to a fifth top steam drum. The water line is kept about 1 ft. 6 in. above the top of the tubes, so that the three upper drums, which are wholly surrounded by the escaping gases, are used entirely for drying the steam. The brick setting surrounding this simple boiler is in the form of a square tower. The combustion chamber is placed directly below the mud drums. Deflecting arches of brick force the gases in and out between the two layers of tubes. The boiler is well spoken of as being accessible, effective and durable, and has been rapidly gaining ground in the west and south.

(3) *Babcock & Wilcox Boiler*, Fig. 20, consists of two horizontal longitudinal steam drums, one transverse steam drum connecting these, a number of so-called headers of pressed steel attached to the ends of the steam drum by expanded nipples, and connected by a number of inclined 4-in. tubes; below the bottom headers a transverse mud drum.

Vertical deflecting plates force the gas to make two or three passages across the tubes. When used for gas, this boiler is provided with a combustion chamber placed below and in front of the upper or front headers. As the water becomes heated, it flows upward in the inclined tubes, enters the steam drum, where the steam generated is released, flows backward through the downward legs into the back header, whence it again enters the inclined tubes. The boiler is well known in Great Britain, and suffice it to say that it is a favourite with many blast furnacemen in America, and largely employed.

(4) *Stirling Boiler.*—At some of the modern American furnaces is found the Stirling boiler, which is well known. This boiler consists of three transverse steam drums placed one in front of the other, one transverse mud drum, and three sets of long, bent tubes connecting

each of the steam drums with the mud drum. The gases flow through the nests of tubes at right angles, and escape in the rear of the last nest. The boiler is said to be a very effective steam generator,

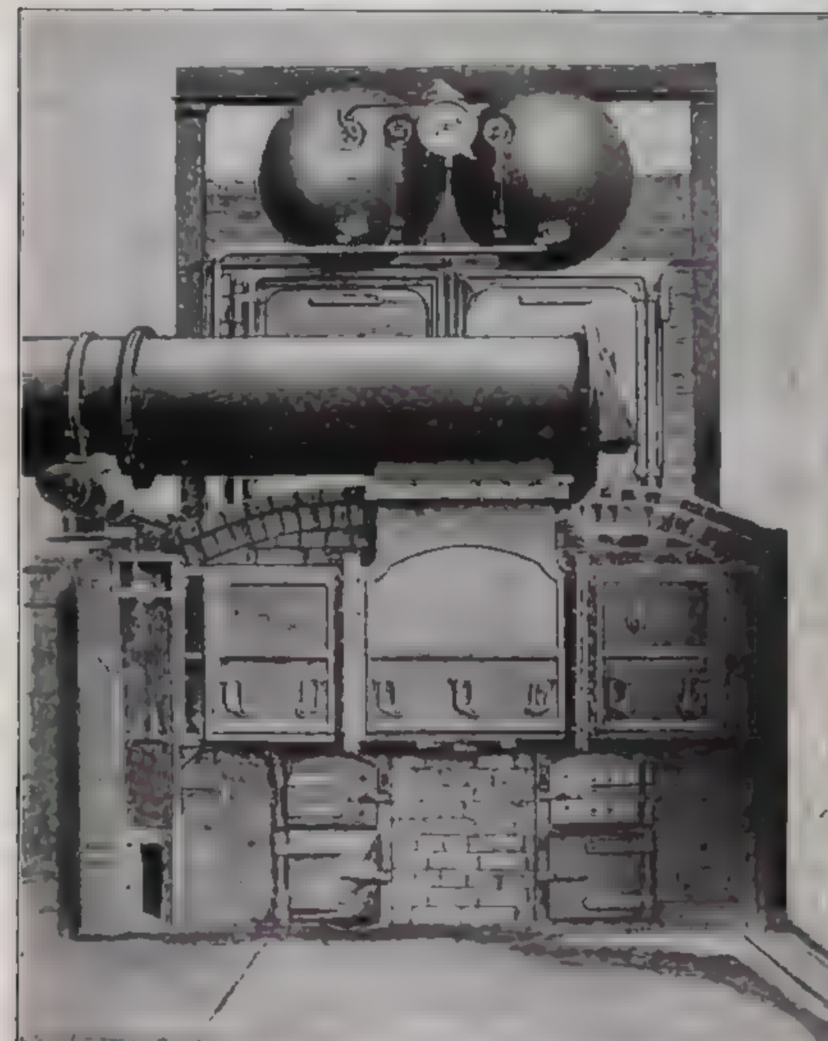


FIG. 20. BATTERY OF BABCOCK & WILCOX BOILERS ARRANGED FOR BURNING BLAST FURNACE GASES

but many blast furnacemen object to the bent tubes on account of the difficulty of cleaning and replacing them.

The boiler equipment for a modern blast furnace generally consists of from 2,000 to 3,000-h.p. of one of the above-mentioned types of boilers.

For heating the feed water, the favourite heaters are:—

(1) The "*Webster Heater*," consisting of a square cast-iron box with numerous shelves down which the feed water trickles, meeting in its flow the exhaust steam from the engines. The heater is provided with an effective oil separator, drains and cleaning doors.

(2) The "*Berryman Heater*," which consists of chambers for in and outgoing exhaust steam, connected by vertical U-shaped brass tubes, which in their order are encased in a strong steel shell, inside of which the feed water circulates under pressure. This heater has the advantage of keeping the feed water separated from the exhaust steam, and from the oil carried away with it.

(3) The "*National Heater*," which is similar to the Berryman, except that all the tubes are straight and have their top ends expanded into a common cast-iron box, through which the steam flows to reach to the return tubes.

(4) The "*Cochrane Heater*," having corrugated brass tubes connecting boxes for admission and delivery of the exhaust steam. The two boxes form the heads of a cylindrical shell of steel plate, inside of which the feed water flows around the corrugated tubes. The corrugations of the tubes prevent the disruption of the heater from unequal expansion.

The *Feed Pumps* are usually of the Worthington or similar cross-compound, plunger-packed, brass-lined pattern, and are often governed by an accumulator, which checks the pump when the pressure in the feed water main gets above its proper limit.

The *Steam Mains* are built of lap-welded steel pipes, with welded steel flanges. All fittings are made in steel castings. For expansion joints long knees or bends are preferred, which give the necessary flexibility or spring.

Blowing Engines.

The modern blowing engine was evolved as a necessity when large volumes of blast under a heavy pressure were demanded for the running of modern furnaces. Up to a pressure of 12 lbs. per sq. in., the old style leather flap valves will stand fairly well, and in the past at most blast furnaces steam economy was not necessary in order to furnish the power required for the furnaces. The problem of blast took on a different aspect when 25 to 30 lbs. of pressure had to be reached, whenever the furnace showed a tendency to hang. Nor was the question of steam economy an indifferent one, when steel plants generally became attached to the furnaces, in which every horse-power spared from the latter was a direct and tangible saving.

High pressure steam, compound condensing engines and metallic blast valves, positive or automatic, then became the main features of the blowing plant as we to-day find it. The engines are required to blow up to 30 lbs. blast pressure with steam at from 120 to 160 lbs., and with piston speeds ranging from 500 to 700 ft. per minute. They are built to run with throttles wide open, and at uniform speed, controlled by automatic governors. Central forced lubrication appa-

ratus, superheater between the cylinders and independent condensers are features of the up-to-date blowing engine. Their dimensions are ponderous, and metal is lavishly put into their base plates and main frames. Bearings, crank and crosshead pins are reaching hitherto unknown dimensions. Pistons are built with large bearing surfaces, and mostly in steel castings. The ingenuity and skill of the engineer has been concentrated on designing the most efficient, prompt-acting and durable valves for admitting and cutting off the air, their purpose being to produce an engine so strong and ample in every detail, that it will run for long periods without breakdowns or delays for repairs; and also that it will run at constant speed whatever the pressure of steam or of the opposing blast, delivering per minute or per hour the certain desired number of atmospheric cubic feet of air. The successful solving of these problems is the fundamental condition for successful modern blast furnace practice.

Amongst the types employed the following are prominent, viz.:—

(1) *The Vertical Disconnected Quarter-crank Compound Type*, shown by Fig. 21.—This engine is built by the Southwark Foundry and Machine Company, of Philadelphia, Pa., under their patents. Each of the high and low pressure engines consist of two housings, the one supporting the steam cylinder, the other the blowing tub. Between the two runs a heavy crank shaft carrying the central flywheel. The steam valves are of the Corliss type. The air valves are of the characteristic Southwark gridiron pattern. The inlet valves are worked positively from the crank shaft; the outlet valves are opened automatically by the difference in blast pressure in the cylinder and in the receiver, but are closed by a positive mechanism. The engines illustrated are now running at the Lebanon furnaces of the Pennsylvania Steel Company. Their general dimensions are high pressure cylinder 42 in., low pressure cylinder 80 in., blowing tubs 84 in. diameter; all 60-in. stroke. The shaft measures 21 in. diameter; main bearings are 20 in. diameter by 30 in. long; crank pins 14 in. diameter, 10 in. long; the two crosshead pin bearings of the forked connecting rods are 10 in. diameter by 8½ in. long. The flywheel measures 20 ft. in diameter. The weight of the pair of engines is about 370 tons. The blowing capacity is 40,000 cubic ft. per minute, at a speed of 53 revs. The engines are guaranteed, if required, to run 60 revs., but have in practice been run up to 70 revs. without any injury resulting. The advantages claimed for this type of engine are:—

(*a*) That the maximum power is developed in the steam cylinder at the moment when the maximum resistance is experienced in the blowing tub.

(*b*) That both steam and air cylinders are easily accessible.

(*c*) That either engine, high or low pressure, can be run independent of the other, in case of a mishap.

(*d*) That the inordinate height and accompanying vibration in the steeple construction are avoided.

(*e*) That the engine house is reduced to more reasonable dimensions.

The cost of this engine delivered at builder's works in October, 1901, was £12,000.

(2) *The Horizontal Disconnected Compound Blowing Engine* **shown by** Figs. 22 and 23.—This type is also constructed by the Southwark

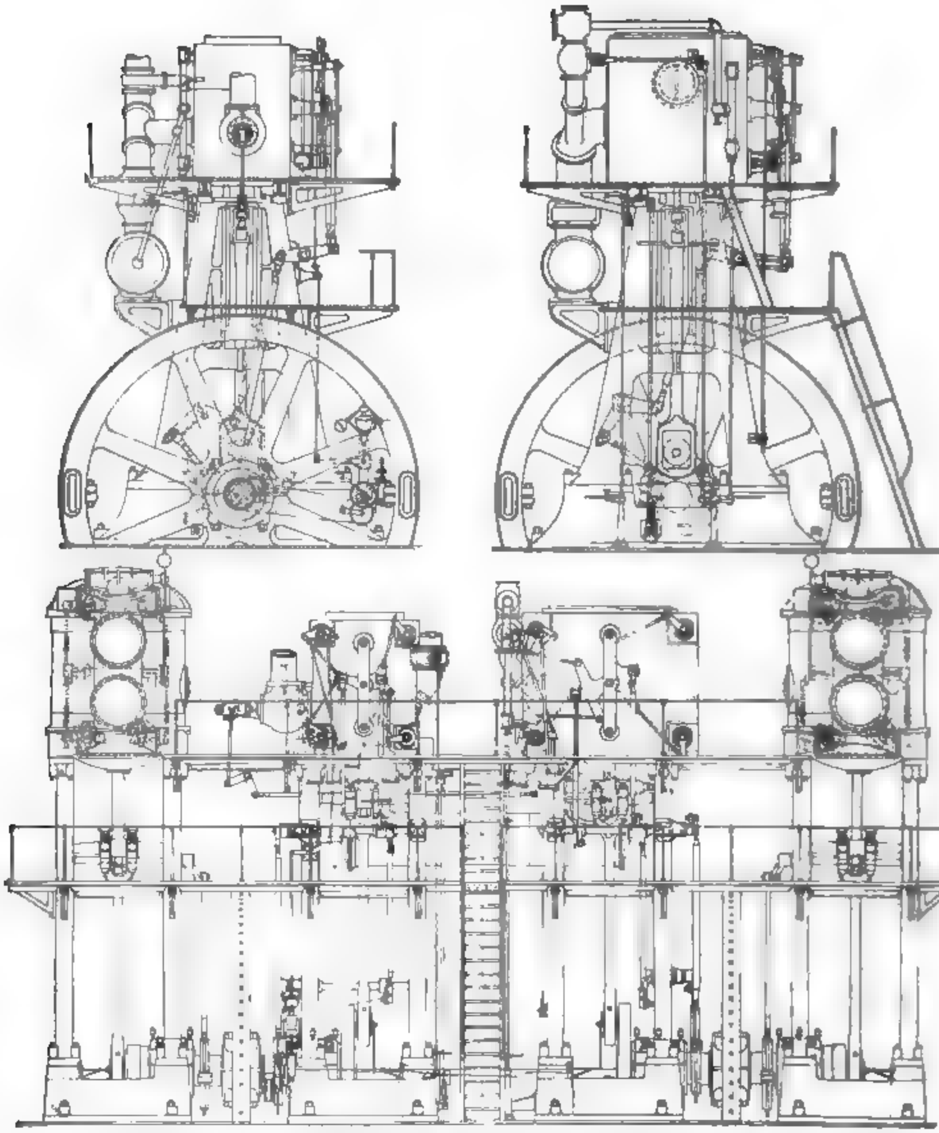


FIG 21.—SOUTHWARK VERTICAL DISCONNECTED QUARTER-CRANK COMPOUND BLOWING ENGINE, AS BUILT FOR THE NORTH LEBANON FURNACES (PENNSYLVANIA STEEL COMPANY), LEBANON, PA.

Foundry and Machine Company, of Philadelphia, under their special patents, and undoubtedly represents much of what is best in blowing engine construction. The solid bedplates, the firm connection between the cylinders, the ponderous piston rods and heavy tail rods, and the accessible design throughout are worthy of attention. The valve

motion is regulated by a sensitive centrifugal governor. The crank shaft is well supported by the frame of the engine, and by a heavy outboard pedestal, between which the flywheel revolves. Between and above the two independent high and low pressure engines is placed an ample steam superheater. The whole installation as I saw it at the new blast furnace at Port Oram was most attractive and confidence inspiring. The general dimensions of this engine are 44-in. high pressure cylinder, 84-in. low pressure cylinder and 84-in. diameter blowing tubs; all 60-in. stroke. The crank shaft measures 22 in. in diameter; main bearings, 21 in. diameter by 40 in. long; outward bearing 21 in. diameter by 30 in. long; flywheel 20 ft. diameter. The crank pin measures 16 in. diameter by 10 in. long, the cross-head pin 12 in. diameter, by 10 in. long. The steam valves are of the flat-faced double port pattern with balancing cover known as the Porter-Allen. One set of valves control the admission, another the exhaust of the steam. The air valves are typical Southwark design modified for horizontal cylinder. The principle of these discharge valves, which, for obvious reasons, cannot be published in detail, is that of a gridiron valve with multiple openings. This valve is automatically opened by the difference in air pressure in the cylinder and receiver, but is closed by a positive mechanical closing device. The air inlet valves are driven positively from an eccentric.

(3) *Duplex Compound Condensing Reciprocating Blowing Engine*, built by Messrs. William Tod & Company, of Youngstown, O.—These engines are shown by Fig. 24. As will be noted, the engines consist of four housings—two carrying the high and low pressure cylinders, the two others the blowing tubs. One blowing tub and one steam cylinder housing are attached to the same bedplate. In the centre between each pair of cylinders is placed a heavy rocking shaft supporting a walking beam. To the ends of this latter are attached the connecting rods for the cylinders. To a protruding arm on the walking beams are fastened the connecting rods driving the flywheel. The flywheel shaft is placed at the end of the engine, where it is supported by heavy pedestals forming part of the bedplates. Engines of this type are in successful operation at the United States Steel Corporation's furnaces at McKeesport, Pa. The valves for the steam cylinders are of the Corliss type governed by an effective centrifugal governor. The air valves are shown by Fig. 25.

It will be seen that the inlet valves are of the mushroom type, 20-in. diameter. They are fitted with dash pots for checking their motion, and are worked positively from the crank disc oscillated by an eccentric on the crank shaft. The outlet valves are of the same type, 18 in. diameter, with 4½-in. lift. They are closed by the positive action of the crank disc, but open automatically. They are also provided with dash pots to cushion their motion. I was assured that these cup-like valves, made of pressed steel, stand the work excellently, and that the engines are giving perfect satisfaction. The dimensions are—40-in. high pressure cylinder, 76-in. low pressure cylinder by 76-in. diameter blowing tubs by 60-in. stroke. The opening through the 20-in. air inlet valves is 9 per cent. of the cylinder area; the opening of the air outlet valves 8 per cent. of

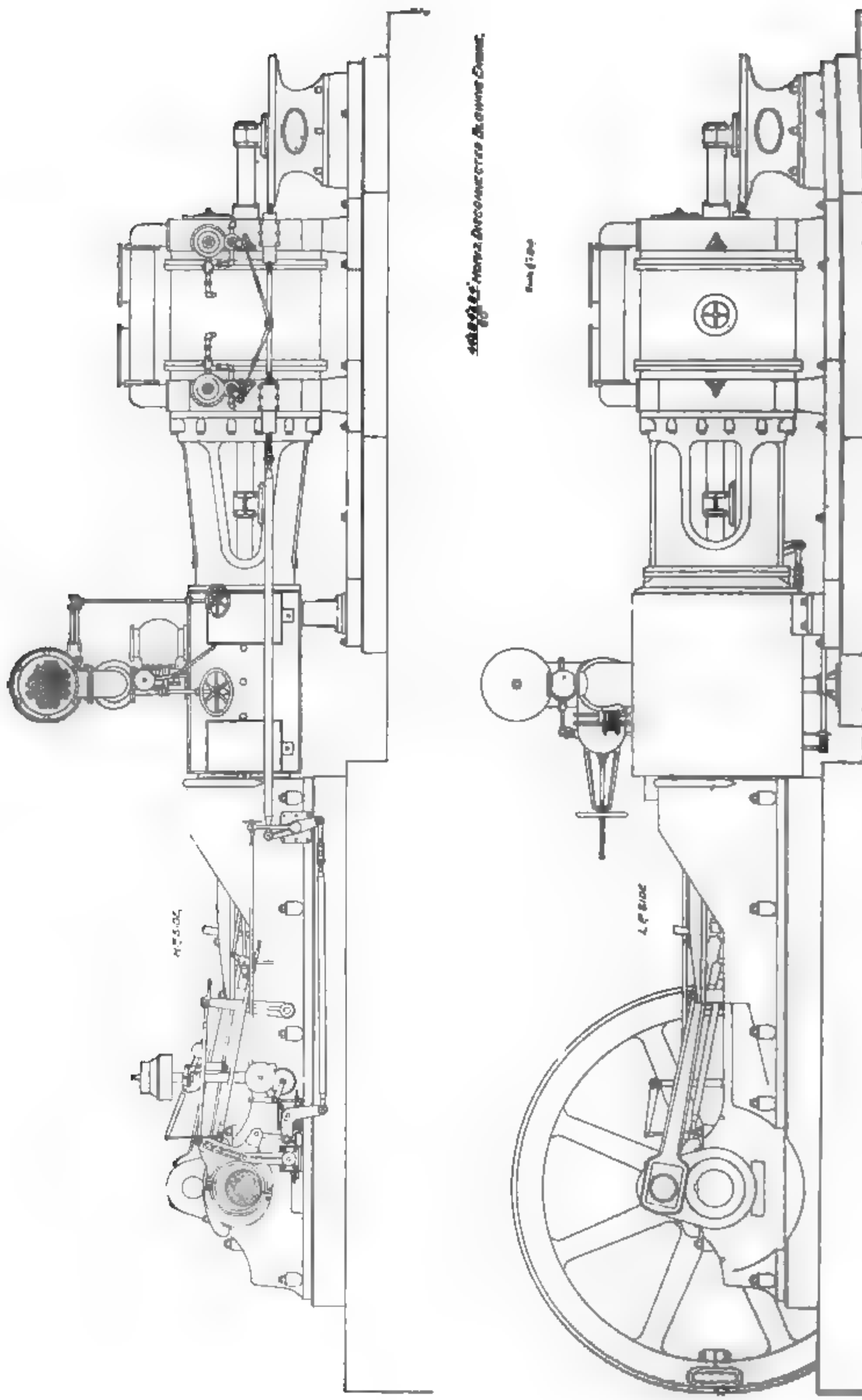


FIG. 22.—ELEVATION. SOUTHWARK HORIZONTAL DISCONNECTED QUARTER-CRANK COMPOUND CONDENSING ENGINES, AS BUILT FOR JOS. WHARTON, PORT ORAM FURNACE No. 2, PORT ORAM, N.J.

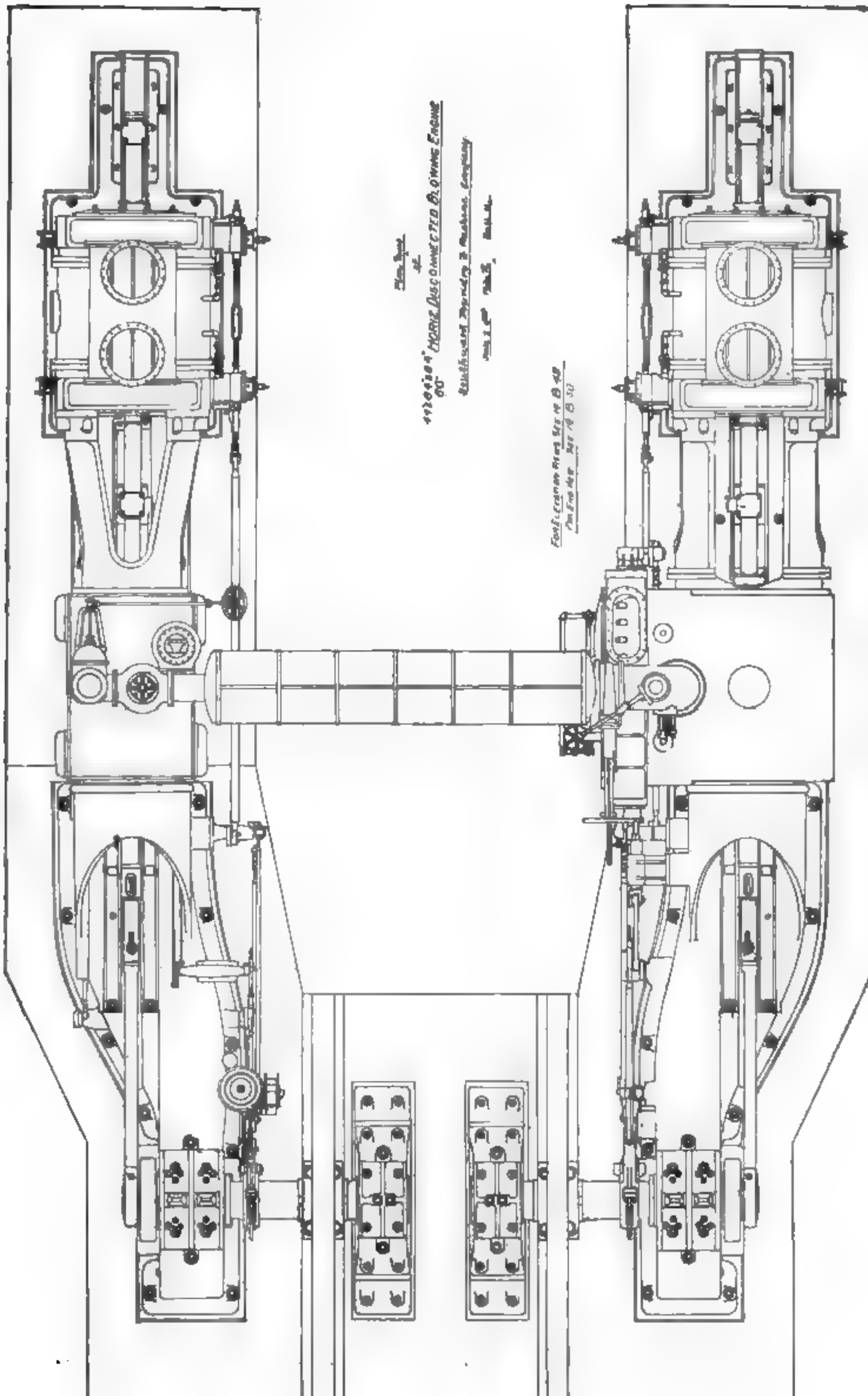


Fig. 23.—Plan. Southwark Horizontal Disconnected Quarter-crank Compound Condensing Engines, as built for Jos. Wharton, Port Oram Furnace No. 2, Port Oram, N.J.

the cylinder area. The diameter of steam pipes are :—High pressure steam 10 in., high pressure exhaust 14 in., low pressure steam 20 in. and low pressure exhaust 22 in.; diameter of air delivery 24 in., diameter of superheater 42 in., number of tubes in same 64—$1\frac{3}{4}$ in. diameter; diameter of flywheel 24 ft., weight of same 50 tons; diameter of main shaft 22 in.; main bearings 20 in. diameter by 40 in. long; beam bearings $18\frac{1}{2}$ in. diameter by 36 in. long; crank pins 11 in. diameter by 9 in. long; walking beam pin 9 in. diameter by 9 in. long; link pins for steam cylinders 9 in. by 9 in.—two for each cylinder; link pins for air cylinder 13 in. by 11 in.—one for each cylinder; diameter of piston rod for steam cylinder 7 in.; diameter of piston rods for air cylinder $5\frac{1}{4}$ in.—two for each cylinder.

(4) *Steeple Cross-compound Condensing Engines.*—Of this type the largest engines are now built for blast furnace work in the United States. Those at the Ohio plant of the National Steel Company were constructed by Messrs. William Tod & Company. They measure 54 in. diameter high pressure steam cylinder, 102 in. diameter of low pressure steam cylinder, 108-in. blowing tubs, all with 60-in. stroke. Each pair of engines are said to weigh 635 tons. Their valve motion is—for the steam cylinders, Corliss, for the blowing cylinder similar to those described and shown by Fig. 25. These engines as seen gave the impression of immense strength. Their bedplates are heavy, their main housings rest on bases 19 ft. long by 10 ft. 6 in. wide. Their flywheel measures 24 ft. diameter, and weighs 50 tons. The steam pipes measure—high pressure steam pipe 14 in. diameter, high pressure exhaust pipe 16 in. diameter, low pressure steam pipe 30 in. and low pressure exhaust 32 in. diameter. The area of two air inlet valves is 1,000 sq. in., area of four outlet valves 800 sq. in.; diameter of air outlet pipes 30 in. Dimensions of superheater 4 ft. 8 in. diameter by 20 ft. long, with 141 2 in. diameter tubes; diameter of main shaft 28 in., main bearings 20 in. diameter by 44 in. long; crosshead surface 30 in. wide by 43 in. long; crank pin 18 in. diameter by 15 in. long; crosshead pin 10 in. diameter by $16\frac{1}{4}$ in. long; diameter of piston rods, steam cylinders, 8 in., air cylinders, 9 in. Three pairs of these engines are furnishing blast for two large furnaces, and can easily deliver 140,000 cub. ft. per minute. One of these furnaces has recently captured the record for a single day's run, producing 806 tons of Bessemer iron in 24 hours, with a monthly average of 634 tons per day.

The steeple cross-compound engine, was first designed by Mr. E. Reynolds, of the Allis-Chalmers Company. The engines constructed by this firm are in use at most of the great modern American furnaces. Their general dimensions are :—Diameter of high pressure steam cylinder 42 in., low pressure cylinder 80 in., blowing tubs 87 in. (84 in. effective) all 60-in. stroke. The flywheel is 24 ft. diameter, and weighs 45 tons. The crank shaft measures 24 in. diameter, main bearings 22 in. diameter by 40 in. long; steam valves are of Corliss type. The air inlet valves are of the Julian Kennedy piston type. This valve deserves special notice, as it is the only valve known which operates with a mathematical absence of clearance.

It consists of an open-ended cylinder extending through both heads of the blowing tub, and also through the blowing piston. The valve

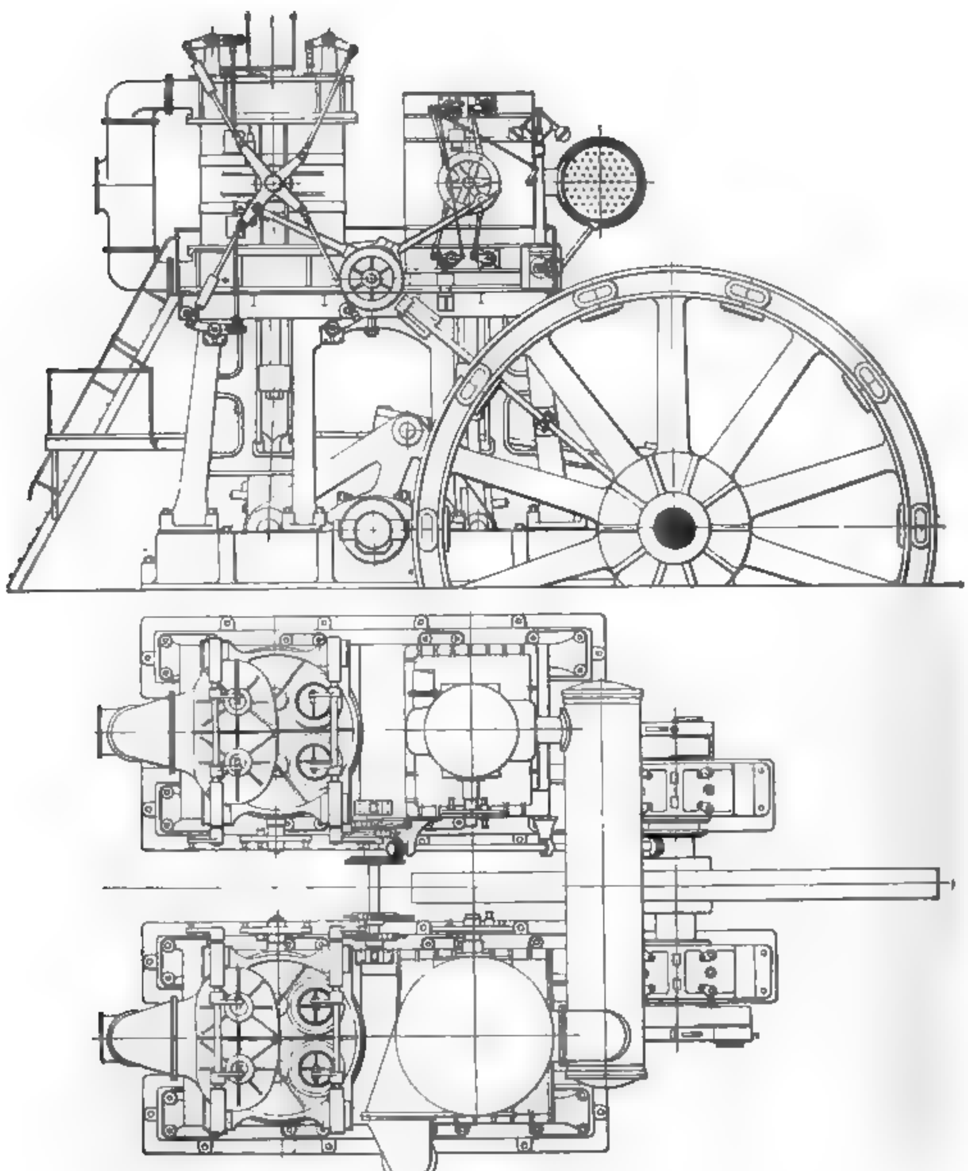


FIG. 24.—DUPLEX COMPOUND RECIPROCATING ENGINES, BUILT BY WILLIAM TOD & COMPANY, YOUNGSTOWN, O., FOR THE MCKEESPORT FURNACES, UNITED STATES STEEL CORPORATION.

cylinder and the blowing piston move independent of each other. At both ends of the valve, perforations are placed in such position, that

when the cylinder is drawn down, the perforations at the top connect the upper centre of the blowing tub with the outside air. When the valve is moved to its top position, the perforations at the upper end of the cylinder are moved upward through the top cover closing the valve, while similar perforations at the bottom end enter through the cylinder head, placing the lower centre of the blowing tub in communication with the outside air. The cylindrical valve is moved by an eccentric and rock shaft motion. The discharge valves are pressed steel cups similar to those shown by Fig. 25.

(6) *Single Vertical Blowing Engines.*—Many blast furnace managers contend up to this day, that for smaller furnaces, the simpler the blowing engine, the more satisfactory the result. These men still

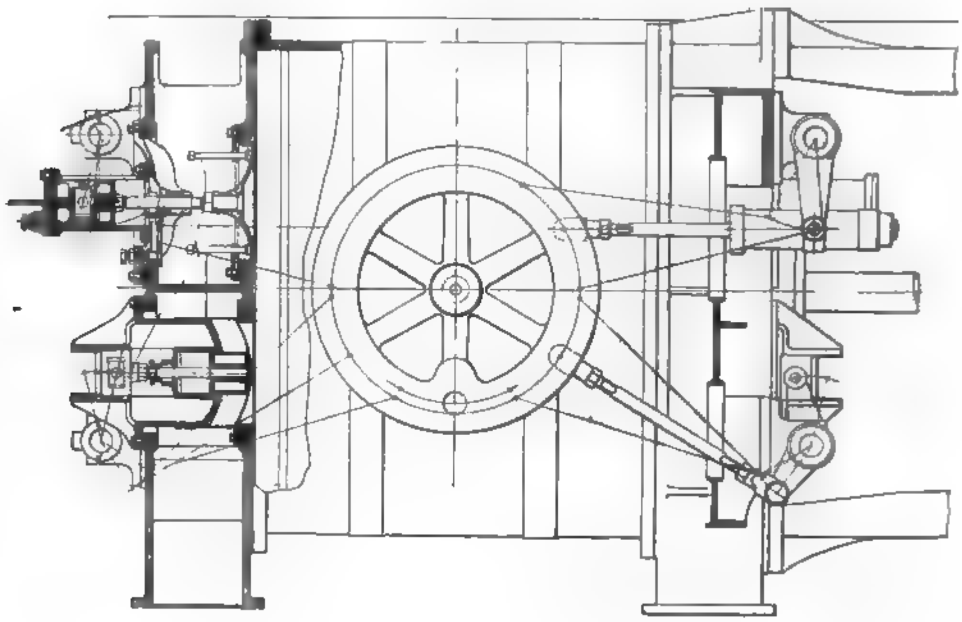


Fig. 25.—Air Valves for Duplex Compound Reciprocating Engines, as Built by William Tod & Company, Youngstown, O.

adhere to the vertical, single cylinder type, built of sufficient strength to blow up to 25 lbs. Fig. 26 shews a Weimer vertical blowing engine, built by the Weimer Machine Works Company, Lebanon, Pa.: diameter of steam cylinder 50 in., blowing tub 96 in., both 60-in. stroke. The valves for the steam cylinder are of Corliss type, regulated by a centrifugal governor. The flywheels are placed outside the flat frames. They measure 22 ft. diameter. The air valves are of Weimer's patented design, shown by Fig. 27. The crank shaft bearings are 18 in. diameter by 16 in. long, crank pins 9½ in. diameter by 10 in. long, crosshead pins 8 in. diameter by 10 in. long, piston rod 8 in. diameter. There are 48 admission valves, consisting of light steel strips held in position by springs. The discharge valves number 30, also consisting of steel strips, which work inside

cages holding them in position. The blowing piston is packed with wood. For simplicity and durability, the engine stands high, and

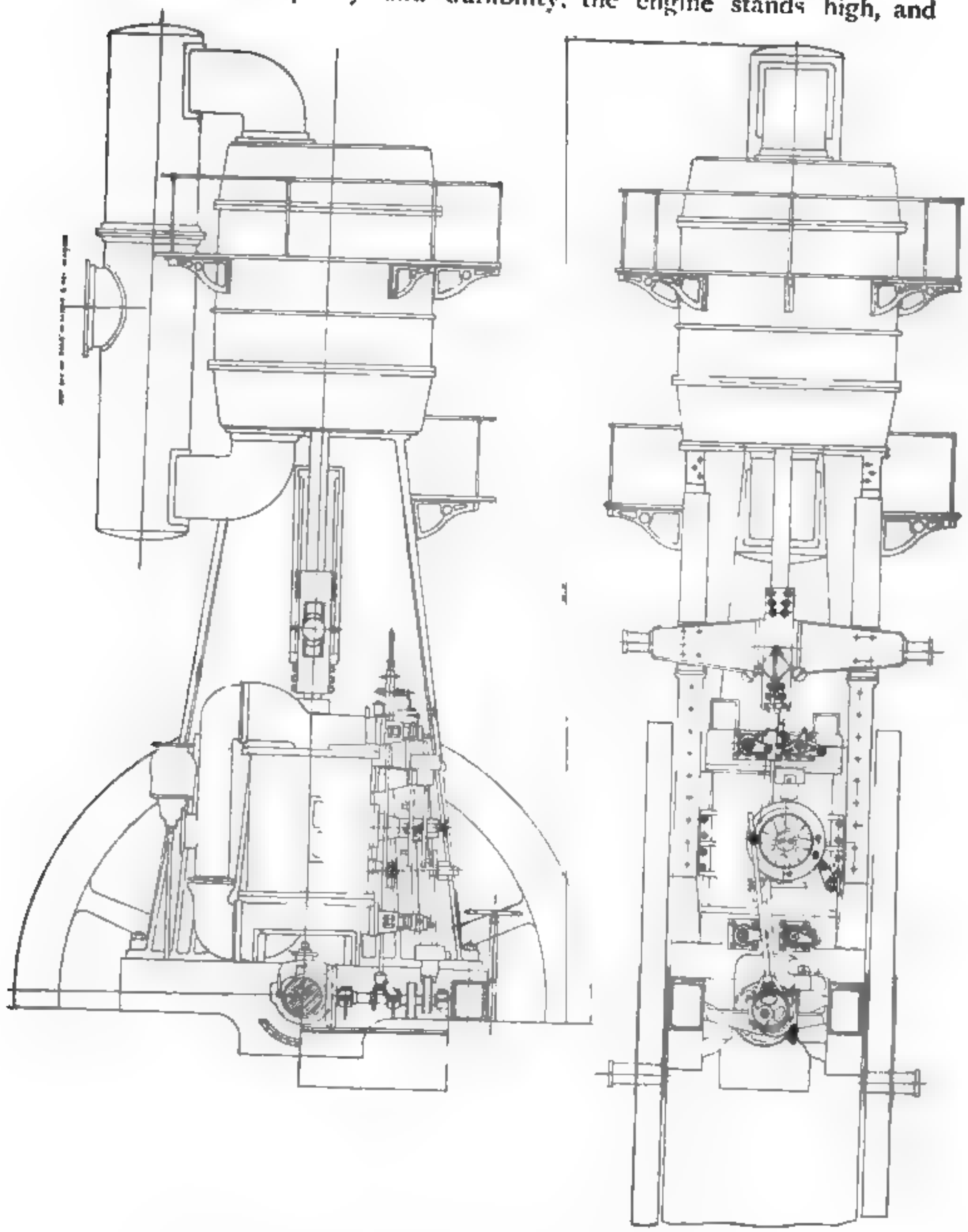


FIG. 26.—WEIMER-CORLISS VERTICAL BLOWING ENGINE.

large numbers of them are now running and being built for furnaces of moderate size.

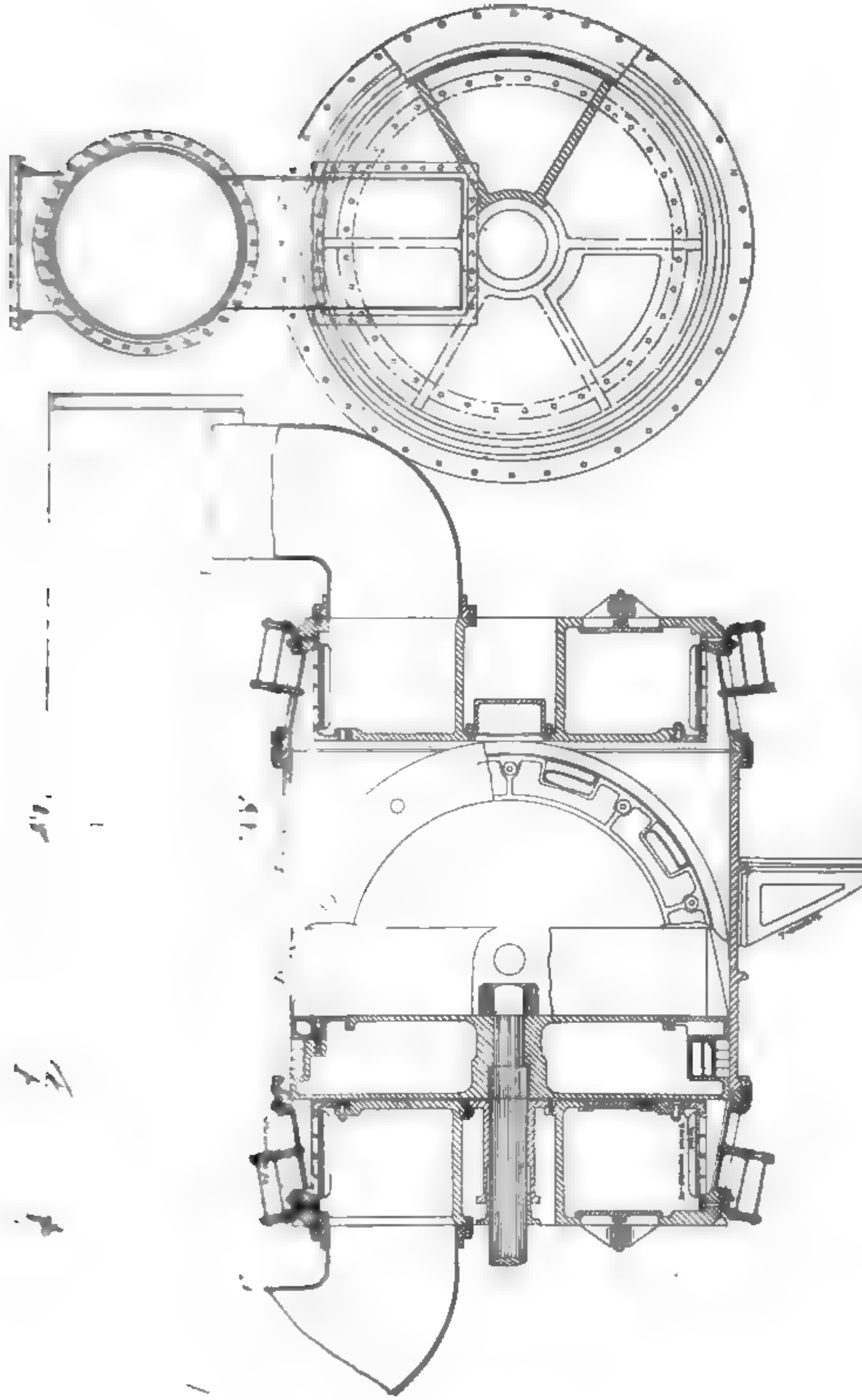


FIG. 27.—WEIMER'S PATENT AIR VALVES.

There has recently appeared a tendency towards the adoption of positive acting valves for both admission and discharge of the air. The quick running gas engines which, undoubtedly, before very long, will come to the front, of necessity require such valves, and, as usually has been the case, necessity has been the mother of invention. Such positive valves are now at work, for instance, at the Isabella furnaces, at Pittsburg. It is claimed for them that for any moderate variation in pressure, the loss in efficiency from too early or too late opening of the valve is kept below 1·7 per cent. For comparison, I may state from my own experience that many old engines with leather-flap valves have an efficiency 40 per cent. less than that of a modern Southwark engine. In other words, the leather flaps give, for the same displacement, 40 per cent. less blast than the gridiron valves. The loss sustained by positive working valves is, therefore, a negligible quantity, especially when due consideration is given to the greater simplicity of the valve motion. The card made by the blast pressure in such an engine, if opening too early, will be like A, Fig. 28, while when opening too late, the card will assume the shape shown by B, Fig. 28. The wavy delivery line in the actual cards C, Fig. 28, is caused by several engines working on the same main. The loss by faulty opening is represented by the cross-hatched area. It seems likely that positive blast valves have a promising future. They will certainly eliminate a complication of machinery, which is anything but an advantage in the modern blowing engine.

Gas Engines.—The use of gas engines for blast furnace plants has not advanced in America as rapidly as on the Continent. The reason for this is probably to be found in the abundance and cheapness of coal. Another reason is also the size of the furnaces, and the financial danger involved in experimenting with them. The difficulty of cleaning the gas is also greater where a large percentage of dust-fine ore is reduced with high pressure blast. In some American furnaces, as much as 50 tons of flue dust is blown out every 24 hours. As yet, there does not exist in the United States a single blast furnace depending on gas engines. Mr. Wehrum, general manager of the Lackawanna Iron and Steel Company, stated in an interview that his new 110 ft. furnaces, now being built, are going to be blown exclusively by gas engines, which are being constructed in the United States.

In several places, gas engines are used for the generation of *electrical power*, which is rapidly being adopted for driving the auxiliary machinery around the furnace plants. The current mostly used in American iron works is direct. The voltage selected varies from 500 to 220. Electricity is being employed for operating hoists, ore and limestone crushers, larries for the stock charging, bells, pumps and condensers, also for tap-hole machines.

Pumping Plant.—A modern American blast furnace requires from three to five or even six million gallons of water per 24 hours. Ample provision is invariably made in arranging for an abundant supply and reserve pumping power. Besides the well-known Worthington type, a favourite pump employed at recently constructed furnace plants is the three-cylinder compound pump, constructed by

Messrs. Laidlaw, Dunn & Gordon, of Cincinnati. These pumps are built for a capacity of from five to six million gallons each per 24 hours. The water is sent to the tuyeres under a pressure of from 15 to 25 lbs. per sq. in. To obtain the necessary head, the favourite device is that of a standpipe or plate cylinder from 15 to 20 ft. in diameter, and from 90 to 125 ft. in height. The standpipe is well bolted down to a solid

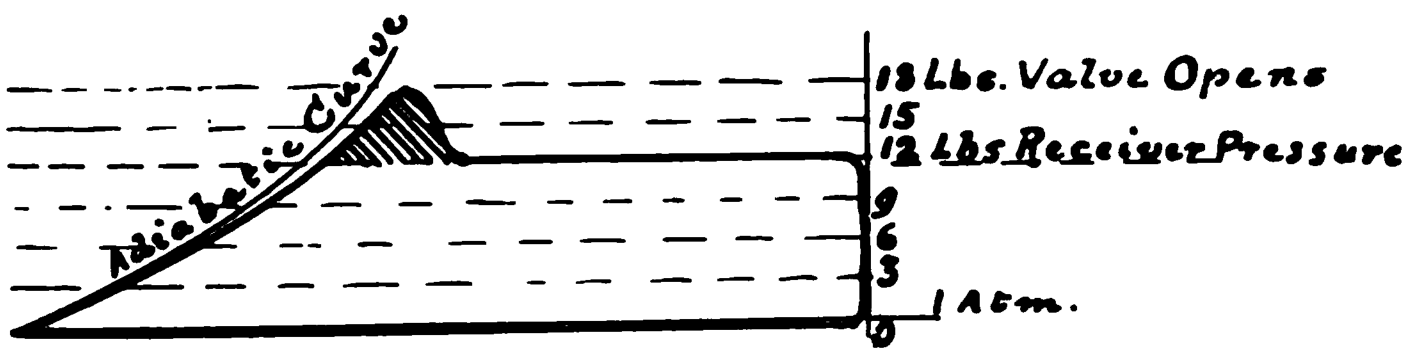


FIG A, OPENING TOO LATE

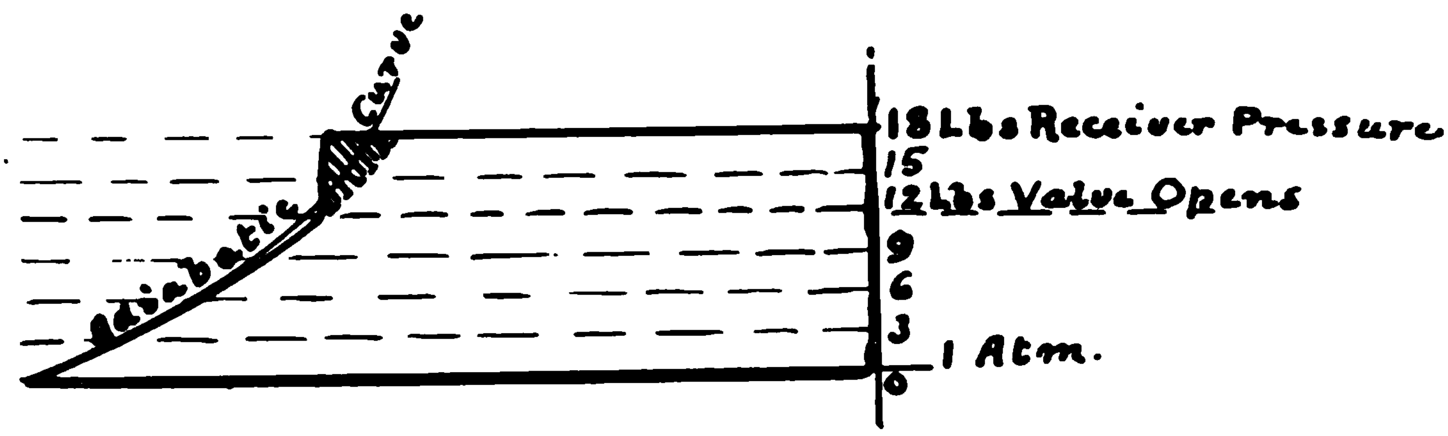


FIG B. OPENING TOO EARLY.

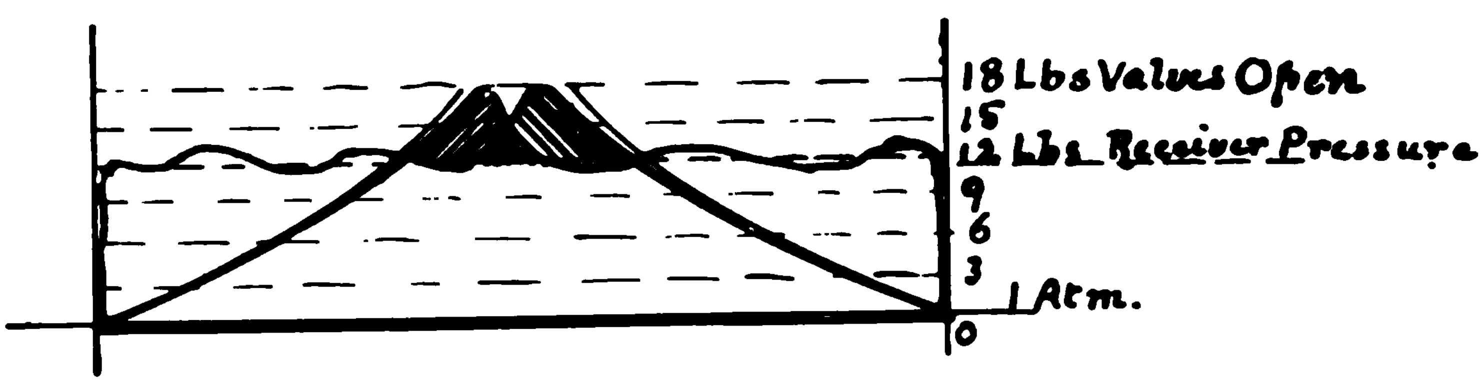


FIG C. CARDS AS ACTUALLY SEEN.

FIG. 28.—INDICATOR CARDS FROM BLOWING TUB, WITH POSITIVE VALVES, SHOWING EFFECT OF TOO LATE AND TOO EARLY OPENING.

foundation, and is provided with internal stays which guard against collapse from wind pressure. The standpipe is also provided with effective strainers, overflow and drain pipes. The pumps are often governed by accumulators, regulated by the pressure in the standpipe.

Condensers.—The condensers are in all cases independent of the engines and common for the entire steam plant. The systems mostly

in favour are the counter-current, gravity condensers, such as are designed and built by the Worthington Pumping Engine Company, shown by Fig. 29, or according to the Weiss system, as shown by Fig. 30.

A characteristic of these condensers is the use of separate water

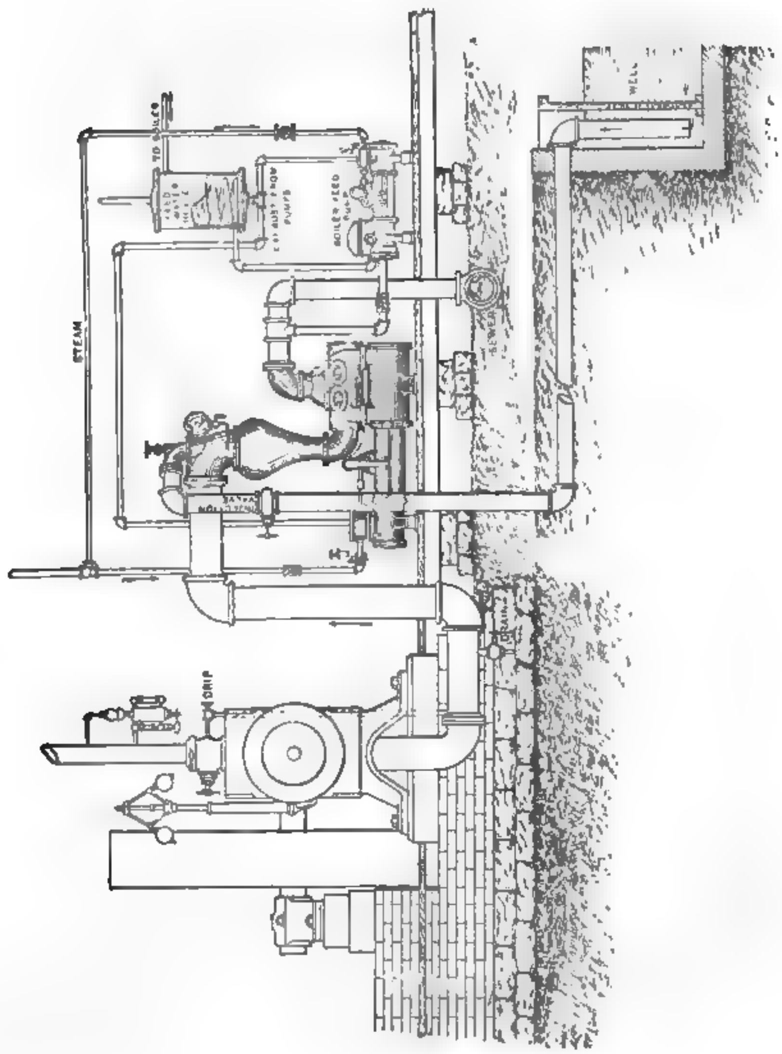


Fig. 29.—Worthington Central Condenser.

and dry vacuum pumps. The former handle simply the water for condensation, which they discharge into the condenser. The condenser is placed 30 ft. above the hot well. The water falls into the latter by gravity against the pressure of the atmosphere. As the condenser has no connection with the suction pipe of the water pump, except through that pump, the vacuum in the condenser aids to lift the injection water. The sectional view of the Worthington central

condenser shown by Fig. 29 explains itself. The Weiss condenser is similar in principle to the Worthington. Two independent vacuum pumps and two water pumps are generally provided for one condenser, so that if one set should get out of order, the other set is ready for use. By this arrangement, the chance of disturbances or stoppage of the condenser is greatly reduced.

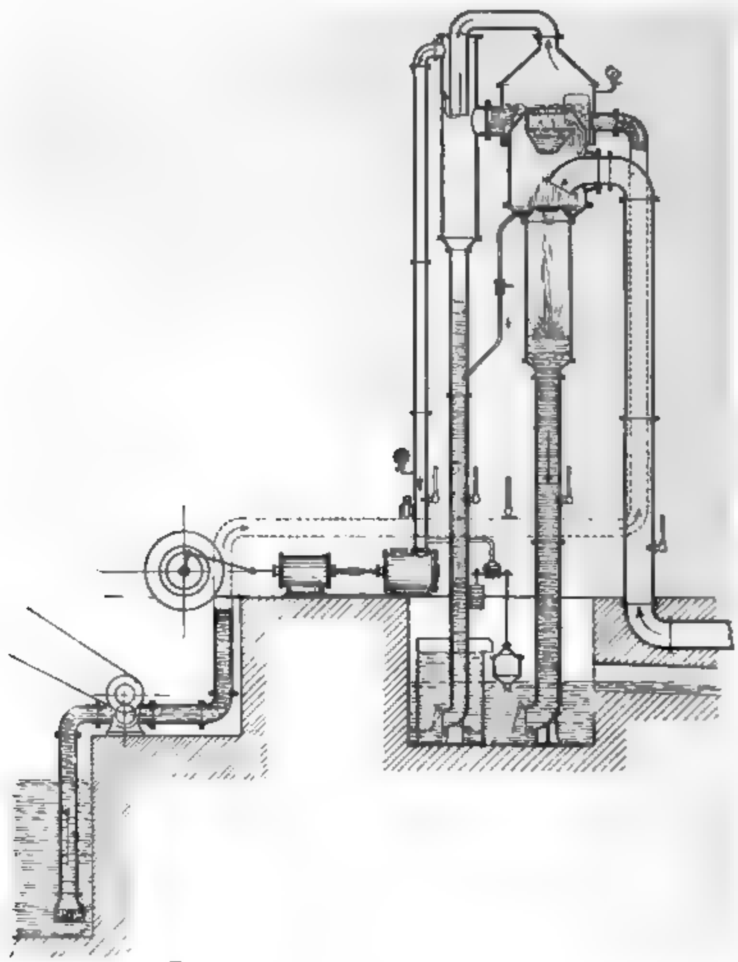


FIG. 30.—WEISS COUNTER-CURRENT CONDENSER.

Typical American Specification for a Standard Modern Blast Furnace Plant to produce an average of 350 Tons per Day, with Connellsville (equal to Durham) Coke, and an Ore Mixture containing 50 per cent. iron.

Furnace.—Height of stack, 100 ft.; diameter of bosh, 22 ft.; diameter of hearth, 14 ft.; diameter of bell, 11 ft.; diameter of stock

line, 15 ft.; height of bosh above tuyeres, 14 ft; height of tuyeres above hearth, 8 ft.; number of tuyeres, 12—6 in. diameter. Tuyeres and breasts of cast copper, containing not less than 99½ per cent. copper. Number of bronze bosh cooling plates, 168, placed in 7 rows. All piping around bosh and tuyeres 1¼ in. diameter. Water pressure at tuyeres, 20 lbs. per sq. in. Skip hoist, double or single, capacity per trip, two tons of coke or four tons of ore. Bell worked by steam, hoist, by electric motor. Stock yard with parabolic steel pockets, above which are mounted inclined elevated tracks. Storage yard arranged according to conditions. Furnace charged by means of electric larries supporting scales and running on overhead tracks; capacity of each larry, two tons coke, four tons ore.

Stoves.—Four Cowper or other approved fire-brick stoves. Height, 100 ft. by 22 ft. diameter. Spearman-Kennedy retreating gas valves, 20 in. diameter. Mushroom type water-cooled hot blast valves, 26 in. diameter, with Berg's removable bronze seatings, 44 in. diameter. Mushroom type chimney valves with water-cooled seats. Separate draught stack for each stove, 160 ft. high, 6 ft. inside diameter, brick lined.

Boilers.—2,500-h.p. vertical water-tube boilers, fitted with combustion chambers; steam pressure, 160 lbs. per sq. in., each boiler having independent smoke stack.

Gas Piping.—Two downcomers, 6 ft. 6 in. diameter each, two dust-catchers, 20 ft. by 40 ft.; separate smaller dust-catcher for each stove and boiler.

Engines.—Two pairs independent, compound, horizontal or vertical, condensing engines, high pressure steam cylinders, 44 in., low pressure cylinders, 84 in., blowing tubs, 84 in. diameter, all 60-in. stroke; revolutions from 50 to 60 per minute. Steam valves of Corliss type; in and outlet air valves, worked positively by means of eccentrics and rock shafts.

Condenser.—Of central Worthington or Weiss counter-current type, sufficient for all engines round the plant.

Pumping Plant.—Feed pumps, plunger packed, in two units, each sufficient to supply all boilers.

Service plant, capacity 9,000,000 gallons of water per day, in three units, compound engines—any two sufficent to supply the furnace.

Heater.—Webster type, 2,500-h.p. capacity.

Standpipe.—100 ft. by 20 ft. diameter, with strainers.

Electric Plant:—Of sufficient size, direct current, 220 volts.

Slag Handling Plant:

First Alternative.—Slag pit, 30 ft. diameter, 40 ft. deep. Walls of brick in cement. Automatic grab bucket of five tons capacity suspended from overhead crane worked by electric motor. Sufficient number of iron universal dumping cars for removing slag.

Second Alternative.—Five Weimer slag cars of 200 c.f. capacity fitted with steam power dumping device.

Metal Handling Plant.—Casting machine, Davis, Hartman, Uehling or Heyl & Patterson type, driven electrically. Eight 20-ton metal ladle cars.

Motive Power.—Three standard gauge locomotives, 16-in. by 24-in. cylinders, four wheels coupled saddle tank type.

Buildings.—Engine house: steel frame with brick filling, slate roof, fitted with 25-ton electric travelling crane, commanding engines, pumps, and other installations. Cast house: steel frame, slate roof, corrugated iron siding, covering the working floor around the furnace, skimmers and metal ladles. Boiler house: steel frame, slate roofing, fitted with coal and ash conveyors and coal hoppers. Offices and laboratory, fitting and blacksmiths' shops according to circumstances.

A plant as described above will, according to foundation and other local circumstances, cost from £160,000 to £200,000.

CHAPTER VII.

Stocking and Charging Materials at the Furnace Plants.

At the older and less fully equipped furnaces, the loaded railroad cars arriving from mines, docks, quarries and coke ovens are pulled or pushed up a line of trestles or elevated tracks, where they are unloaded by opening the bottom or side doors of the cars, letting the materials slide into bins or pockets, or directly on to the ground, afterwards to be transferred into charging barrows, filled in the first case by gravity, in the second by hand shovelling. This method, however, requires a large number of men and barrows, and becomes practically impossible when the output of the furnace is increased. Means have, therefore, been devised at the more modern plants to transfer the materials from the pockets into the skip of the hoist by means of mechanical contrivances. The above described method refers to furnaces which receive their materials from day to day as required. Most of the large American furnaces, however, depend on Lake Superior ore, which can only be moved during the shipping season—May till November. During the winter months the furnaces draw on a stock laid in during the preceding summer. When a furnace produces 600 tons per day, [illegible] tons of ore must be provided for every winter day, or, in [illegible] words, 150,000 tons of ore per furnace must each autumn be [illegible] on the yard, and rehandled as required. To accomplish [illegible] an economical and uninterrupted manner, various classes [illegible] have been designed, a few of the leading kinds of [illegible] described below, viz.:—

Brown Bridge Tramway.—These machines are used at [illegible] lake front furnaces, for instance, South Chicago, Lorain, [illegible] Buffalo, and also at the Duquesne and Carrie plants, [illegible] The furnace plants are, in the case of the Lake Shore [illegible] near by and parallel to the docks, where the ore is dis- [illegible] the vessels. The Brown bridge tramway has been des- cribed previously (see pages 416 and 418, Fig. 6). It is, for [illegible] placed so that its hinged overhang, or apron, extends [illegible] the ship, while the bridge span and cantilever cover [illegible] The bridges must be designed sufficiently strong

FIG. 36.—REVOLVING CANTILEVER CRANE, PUNXSUTAWNEY, PA.

to handle a 5- or 10-ton shovel bucket. The ore is unloaded from the ship in the usual fashion, and dumped under the bridge tramway,

Fig. 32.—Hulett Car Dumper for Ore, Ohio Steel Company, Youngstown, O.

which as soon as one section of the yard is filled up, is moved a few feet, continuing the ore pile at full height. The tail end of the cantilever is preferably placed above the pockets, whence the ore and other materials are drawn into the transfer cars, larries or skips. When the ore is to be utilised, a shovel bucket attached to the bridge tram-

way will scoop it up, carry it over the pockets and dump it automatically into them. One man can, by means of the bridge tramway, and with a 5-ton shovel bucket, handle about 2,000 tons of ore per day from storage into service pocket, at the cost of about $\frac{1}{3}$d. per ton. The shovel bucket is at the forward edge armed with long pointed teeth of tool steel, by means of which it will break through even a heavy crust of frozen ore. Such a bucket will shovel blasted rock without any apparent difficulty. With the method explained, the ore is never touched with a hand shovel from the time it leaves the hatchway of the ship until it is deposited in the furnace.

At the Duquesne Furnaces, which are located away from the Lake shore, the ore of necessity arrives in railway cars. These cars are run on to a trestle. The bottoms are opened, and the ore drops into a pocket under the car. From this pocket the ore is drawn off by gravity into 5-ton automatic dumping buckets, which are lifted by the bridge tramway and dumped in the proper place in the yard.

(2) For storing ore for a moderate sized furnace plant, a very cheap and serviceable arrangement is the *revolving cantilever crane*. Fig. 31 shows this crane as installed at the Punxutawney Furnace, Pa.

These cranes are built up to a length of 363 ft. from point to point of cantilever. The track is placed about 70 ft. above the ground, making it possible to pile the ore under the crane to a height of 60 ft. Ordinary automatic buckets are placed under the chutes of the receiving ore pocket, and are filled by gravity. The revolving crane is placed with the trolley above the buckets, which are raised and moved, by revolving and racking, to the point where the ore being handled is to be deposited. At this point the bucket is automatically dumped by being dropped on the ore pile, and the crane returns with the empty bucket to the original position. With a 4-ton crane of this description one man will comfortably handle 1,200 tons of ore per day of 10 hours from the receiving pocket to storage, and will shovel about 1,000 tons per day from the ore pile into the service pocket at the furnace. The crane in working order costs from £8,000 to £10,000, according to size and location. It can be driven by means of steam power or electricity, as desired.

(3) At the Eliza Furnaces of Messrs. Jones & Laughlin, in Pittsburg, Pa., the ore storage plant consists of a number of *high steel trestles* on to which the ore cars are pushed and unloaded. The ore remains where it drops until it is required, when it is shovelled from the ground by means of 5-ton steam shovels running on tracks under and parallel with the trestles. The steam shovel is more positive and rigid than the shovel bucket suspended on a wire rope. For that reason it is preferred by many, but the installation of steel trestles and steam shovels is, when the problem involves storing of 600,000 tons of ore for winter use, more costly than would be a portable installation of cranes, however ponderous these may be.

Amongst the most modern installations for handling the incoming ore supply are those of the Ohio Steel Works, Youngstown, O., and at the Carrie Furnaces, Rankin, Pa.

(4) At the Youngstown plant, the arriving cars are placed on a *Hulett car dumper*, as shown by Fig. 32. The car dumper is in main

FIG. 33.—HULETT BRIDGE CONVEYOR, OHIO STEEL COMPANY, YOUNGSTOWN, O.

arranged like that for coal handling already described. There is the same platform and locking arrangement, but instead of the cover, with its pockets, there is an inclined plane or tray, to which are attached deflectors, which guide and distribute the ore amongst four 20-ton bridge trucks placed on transfer cars alongside of the car dumper. In case of 50-ton hopper cars, the bulk of the ore is loaded near the centre of the car. Therefore, the deflectors are adjusted so as to move it outwards. On gondola cars, on the other hand, the main part of the ore is loaded near the end of the car above the trucks, and the deflectors are in this case reversed so as to send part of the ore in towards the centre. The bridge trucks are mounted on tracks placed on steel transfer cars, which run on ordinary railroad tracks to the bridge conveyor shown by Fig. 33. This bridge conveyor spans the ore storage yard. The bridge cars are one at a time drawn up along one of the four converging railway tracks of the bridge, which coincide with the tracks on the steel transfer cars. The loaded bridge trucks are automatically tipped when they arrive at the place where the ore is to be deposited. At the Ohio Steel Company's works, the storage yard is 250 ft. wide and 2,000 ft. long, the height of the bridge above the base of the ore piles being 80 ft., which, of course, gives very large storage room. The car dumper has a proven capacity of thirty 50-ton cars per hour; but the average speed of working is only fifteen 50-ton cars, or 750 tons per hour, which allows sufficient time for shifting the cars in and out from the dumper. Two conveyor bridges are provided, each of which will take care of 12 railroad cars or 48 bridge trucks per hour. It requires two men to operate each of these conveyors, one lever man, and one man to hook and unhook the cable from the trucks. Two men are also required to operate the car dumper, and two on the switching locomotive.

The conveyor bridges also work a shovel bucket, which scrapes up the side of the ore piles, filling itself with 10 tons of ore. The bucket is lifted and carried by a trolley running on a track suspended under the bridge, and is dumped into the ore pockets at the furnace end of the machine. The approximate price for a car dumper is about £11,000. Its weight is about 200 tons. The price for a conveyor bridge, of course, depends greatly on the span, and the power of the machinery for operating the conveyor; but, constructed for 25-ton loads, they are very expensive machines. Both car dumper and conveyor bridges at the Ohio Steel Company's works are operated electrically, but steam may be used if preferred.

The above data have been given me by Mr. Geo. H. Hulett, manager of the Webster, Camp & Lane Machine Company, of Akron, O., and inventor of the machines, and by Mr. S. McDonald, general manager of the Ohio Works.

(5) A different system has been employed at the latest furnaces of the Carnegie Steel Company, those of the Carrie plant. At this place a car tipple, shown by Fig. 34, deposits the ore from the railway car into six standard 10-ton automatic dumping buckets placed on a transfer car. This car is run under a Brown bridge tramway of massive dimensions, which controls the transfer tracks as well as

the storage yard and the parabolic suspended steel pockets at the furnaces. By means of the bridge tramway, the buckets are successively picked up from the transfer car, and the contents deposited either directly into the pockets or in the storage yard. During the winter, the dumping buckets are exchanged for shovel buckets, the ore being lifted as required for consumption in the furnaces. There is one of these plants serving each pair of the four furnaces. That for Nos. 1 and 2 furnaces, Fig. 35, has a bridge tramway with 132 ft. span, while that at Nos. 3 and 4 furnaces, which is shown in plan and elevation by Fig. 39, measures over all 563 ft. 1½ in., and represents one of the most perfect installations of this kind. As will be seen, each of the two towers supporting the bridge is carried by the framing of the pockets. These pockets are built of ¼-in. steel plates, suspended from the framing without any braces or supports whatever. The steel plates are given parabolic shape, and are, therefore, not distorted by the ore resting on them. Near the apex of the parabola, chutes for drawing off the ore are arranged, so that the pockets can be entirely emptied without shovelling. When the ore is drawn off through the chute, it falls into the hopper of the elecric larry or transfer car, shown by Fig. 36. The hopper of the larry is supported by a scale fitted with six weighbeams, which can be separately adjusted, and which are kept under lock and key, but in full view of of the operator. The larry is run on a suspended overhead track. The overhead track is preferred to one resting on the ground, as it will always remain free and clean, even if some ore or coke should be spilled from the larry. The weigh-master, who is seated on the larry, operates the chutes of the pockets, at the same time watching the weighbeam set to regulate the amount of ore which he is drawing. He also runs the larry from the pockets to the skip of the inclined hoist, and empties the charge into the same.

At the Ohio Steel Company's works, two men handle the ore supply for one furnace producing an average of 600 tons per day, and with a best record of 806 tons in 24 hours. A third man draws coke and limestone into stationary larries placed on either side of the descending skip.

A unique and interesting arrangement for charging material into the hoist skip was seen at the North Lebanon Furnace, Lebanon, Pa. This furnace uses exclusively roasted Cornwall ore, which is reduced with Connellsville coke and a very pure local limestone and dolomite. There is at the foot of the hoist incline one large receiving hopper, measuring 40 ft. by 50 ft., divided into four compartments. One half of the hopper nearest the furnace is reserved for coke. The central portion of the opposite half serves for ore, and the two end portions for limestone and dolomite. The skip of the hoist rests on a weighbridge supporting the bottom part of the hoist incline. One man operating the chutes from his position in front of the weighbeams by means of pneumatic cylinders, will successively fill the hoist skip with the proper amount of ore, limestone and coke, hoist the same to the furnace top, work the bell and sound the furnace. A labourer assists him to keep clean the hoist pit and weighbridge, which latter is adjusted daily.

The Lebanon Furnace produces on an average 225 tons of Bessemer iron from a very lean ore, averaging about 45 per cent. It seems

FIG. 34.—CAR DUMPER, CARRIE FURNACES.

as if the greatest possible economy in the arrangement for charging a blast furnace has been reached in this installation.

Furnace Hoists.—The reciprocating, vertical hoist, whether driven by steam, electricity, compressed air or water, is totally obsolete in

Fig. 35. Car Dumper and Bridge Tramway, Carrie Furnaces, Nos. 1 and 2.

America. It is too slow to handle the quantity of material required for a large output, and too costly in human labour to be tolerated. Inclined skip hoists have universally taken its place. The first of this type of hoist was working at the Lucy Furnaces, Pittsburg, as early as 1879. The original skip hoist was fitted with double tracks and two skips, dumping their contents alternately into a funnel concentric with and suspended above the bell. The distribution by this arrangement was, however, not entirely satisfactory. The next step forward was taken when the late William Rothoff designed a double skip hoist, depositing the charge into a "cylindrical receptacle surmounted by an oval hopper placed above the top platform of the furnace." This patent is now controlled by Mr. Walter Kennedy, consulting engineer, Pittsburg, who has modified the Rothoff hoist.

When constructing the Duquesne Furnaces, M. A. Neeland introduced a new system of hoist. On electrically driven scale cars are placed cylindrical tubs, the bottoms of which are closed by a small bell. The tub is carried from pocket to pocket, until it carries the proper furnace charge of ore or coke. It is now run under the single track inclined hoist, to the trolley of which is attached a hook. This hook grips the tub and carries it bodily to the top of the furnace, where it is deposited on a seat concentric with the bell. At the same time, the small bell which closes the bottom of the cylinder is lowered, and the charge is deposited in the hopper. The empty tub is then picked up and lowered until it is again placed on the travelling scale car.

The Brown hoist differs from that of Mr. Walter Kennedy, in that a single track only is used on which travels a skip without counterbalance. The skip is emptied into a funnel-like revolving hopper supported on a circular track above the furnace bell, and fitted with an eccentric spout. The main sheave at the top of the hoist around which the hoist rope runs is, by means of a series of bevel gears, shafts and a ratchet coupling, connected with the revolving hopper, or the so-called distributor, which it turns as long as the shaft is running in one direction, viz., that which lowers the skip. When the skip is hoisted, the ratchet or slip coupling leaves the distributing hopper stationary. The gears connecting the main sheave with the distributor are so calculated that for each trip of the hoist, the funnel turns an angle of, say, 87 degrees. If, therefore, a skip of material is deposited due north, the next skip will be deposited east 3 degrees north, the following south 6 degrees east, the third west 9 degrees south, and the fourth north 12 degrees west. Continuing to revolve, the distributor will deposit each new charge in a direction slightly different from the one preceding it. There is no arrangement known which will give so positive and absolutely reliable a distribution of material in a blast furnace as the Brown distributor. The hood supporting the distributor rests on the rim of the hopper, and the mouth of the spout is closed by an automatic cover. When the bell is lowered, the rising gas is, therefore, prevented from escaping or igniting. The hoist is well known. Objections have been raised to the method of

carrying a skip holding perhaps three tons of material up an inclined track, without providing some sort of counterweight or counterbalance. This, however, is possible and practicable, due to the perfect friction couplings and brake, which form parts of the Brown hoisting engine.

Fig. 56.—Electric Larry, with Suspended Track.

At the Pioneer Furnaces at Thomas, near Birmingham, Ala., railway trucks with hopper bottoms are run under the various ore pockets or arrive loaded from the mines. These trucks are moved across a pit at the foot of the hoist incline. In this pit has been

lowered a push car, also called "ground hog," similar to the one which works the tipple described on page 433. This ground hog ascends behind the car and moves it bodily up the incline to the top of the furnace, where it is arrested in a central position above

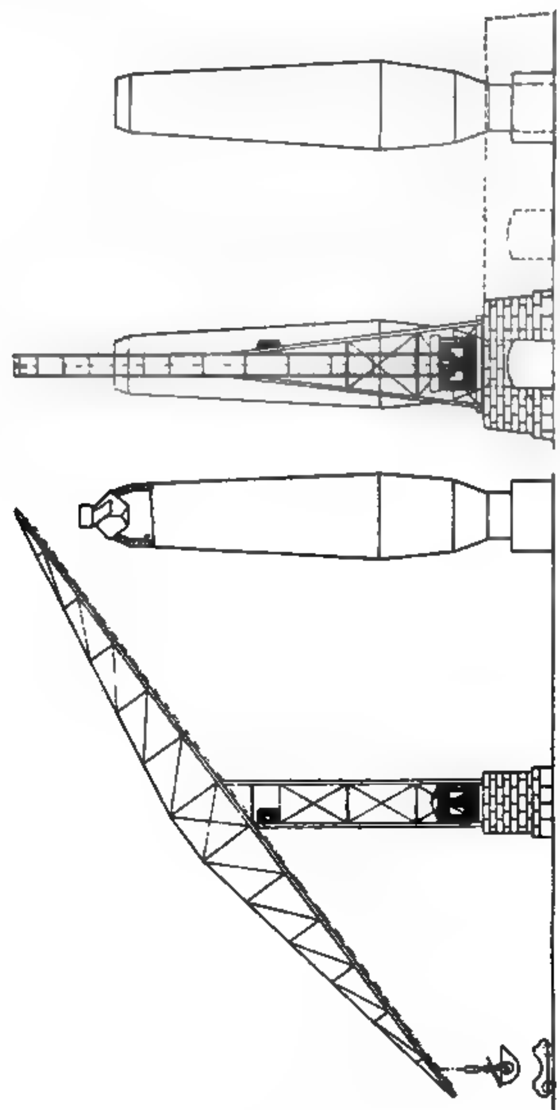


FIG. 37.—BROWN INDEPENDENT CANTILEVER HOIST.

the bell. The hopper bottom is automatically opened, the ore or coke descending directly on to the top of the bell. Under certain local conditions, where ore arrives regularly and as required over private railways, and where coke is manufactured in the furnace yard, this system has, undoubtedly, much to recommend it.

At the Ohio Steel Company's works was seen an electric hoisting engine, which, slowly started, automatically speeds up, slows down and stops on the skips reaching the top and bottom of the bridge. The effect is obtained by regulating the resistance in the electric controllers by means of a button rope worked by the moving skip. Electric hoist engines are gaining in favour.

The Brown Hoisting Company have recently built and erected for a furnace in Austria a novel hoist, consisting of a 5-ton cantilever crane entirely separate from the furnace. Automatic dumping buckets carried on cars arrive under the cantilever crane from coke shed and roasting kilns charged with ore and coke. The buckets are picked up by the crane, carried to a point above the furnace top, and dumped into the distributor. They are then returned to the transfer car, and the next loaded bucket is hoisted. The railway track for the transfer car is built in the shape of a loop, the cars proceeding in an endless procession under the crane and back to the coke storage and roasting kilns. The capacity of such a cantilever is amply sufficient for charging the largest furnace. It is, undoubtedly, a certain advantage to have the hoist entirely independent of the furnace stack. Being of American design, and of entirely modern type, this arrangement is illustrated in Fig. 37.

CHAPTER VIII.

Handling of the Products of the Furnace.

Flue Dust.—When furnaces are smelting a large percentage of dust-fine ore, and are driven as hard as are the American furnaces, the flue dust escaping with the gas is presenting a problem which has to be dealt with. At present the usual method is to deposit the bulk of the dust in large dry dust collectors or dustcatchers. By increasing the area through which the dust must pass, the velocity of the gases and dust is suddenly arrested, and the dust, being the heavier of the two, will move more rapidly, striking the walls of the dustcatcher, whence it is supposed to—and a great percentage really does—fall to the bottom of the receptacle. The main dustcatcher is located at the bottom of the downcomer, but similar dustcatchers on a smaller scale are usually found also in front of every stove and boiler. Water sprays have occasionally been used, but are not favoured, as they are troublesome and must be constantly kept in order. To prevent the blowing out of a great amount of dust, the modern furnaces are often equipped with numerous gas openings all around the circumference of the furnace top. The pipes leading from these openings are connected outside the furnace, so that the gas arrives at the foot of the furnace through one, or at the most two, main downcomers. In some of the newer furnaces, for instance Cambria No. 2, the gas outlets rise perpendicularly from the furnace top, and

unite above the same into large downcomers. This plan has much to recommend it. The argument against one-sided downcomers is that, when the charge is being dropped from the bell, the fine ore falls in a thin sheet through the current of gas passing from the

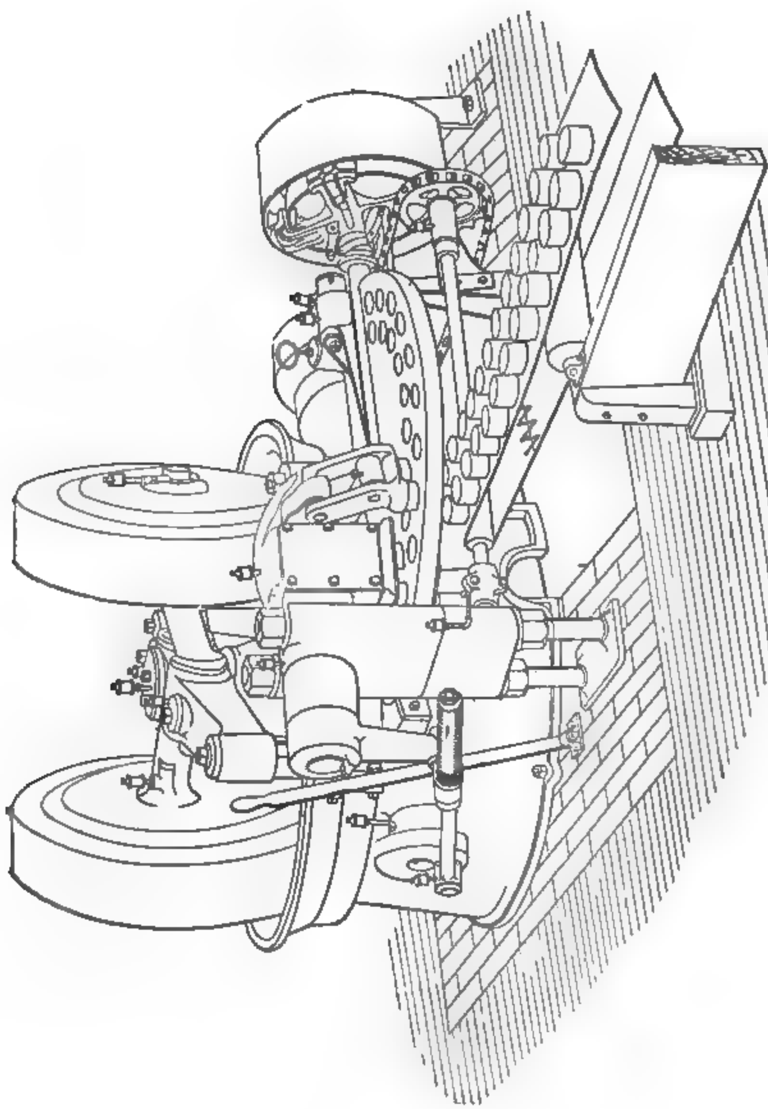


FIG. 38.—THE WHITE BRIQUETTING MACHINE.

centre of the furnace towards the downcomer opening. A cloud of fine particles of ore will, therefore, be deflected and pass down through the downcomer, without ever having reached the stock line of the furnace. With coarse ore and moderate driving, this objection, I think, has very little weight.

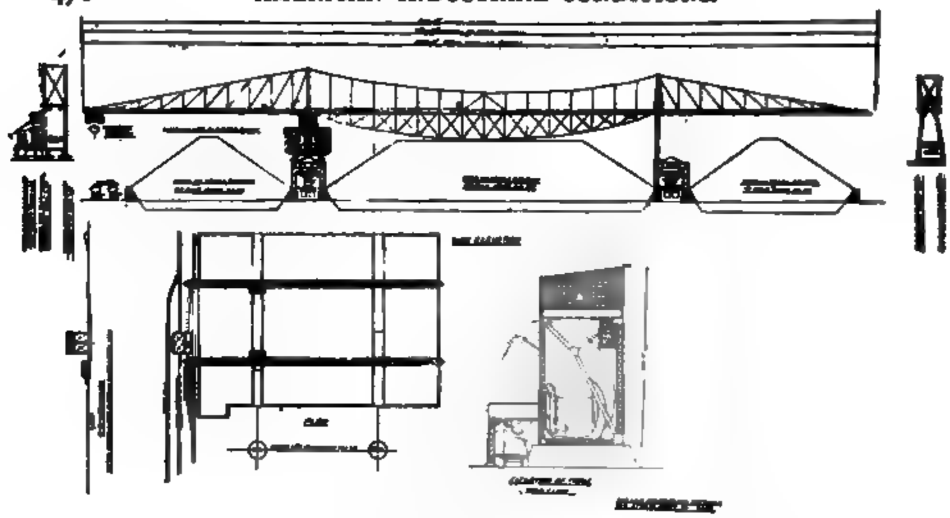


FIG. 39.—STORAGE YARD AND BRIDGE TRAMWAY, TIPPLE AND PARABOLIC POCKETS, CARRIE FURNACES, NOS. 3 AND 4

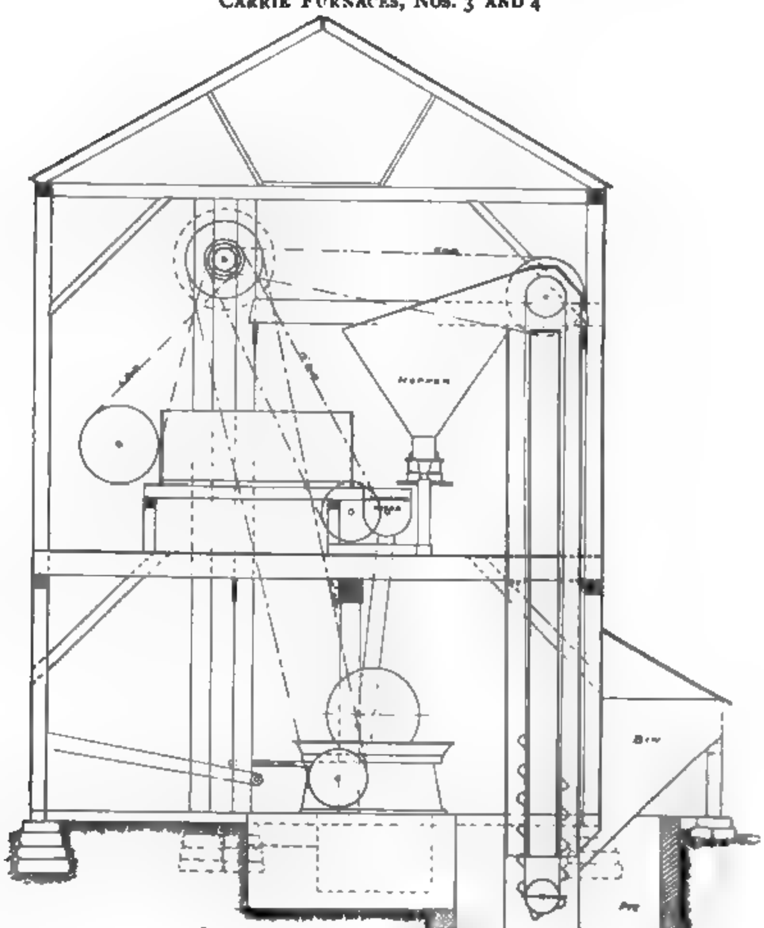


FIG. 40.—BRIQUETTING PLANT, BUILT BY CHISHOLM, BOYD & WHITE, CHICAGO.

When using rich ores like Mesaba, the dust collected in the first dustcatcher is high in iron. At a certain plant near Pittsburg, the analysis of the dust is as follows :—

	Per cent.
Iron	56·00
Lime...	4·00
Carbon	8·00

Such dust is in itself a good ore, which is briquetted and returned to

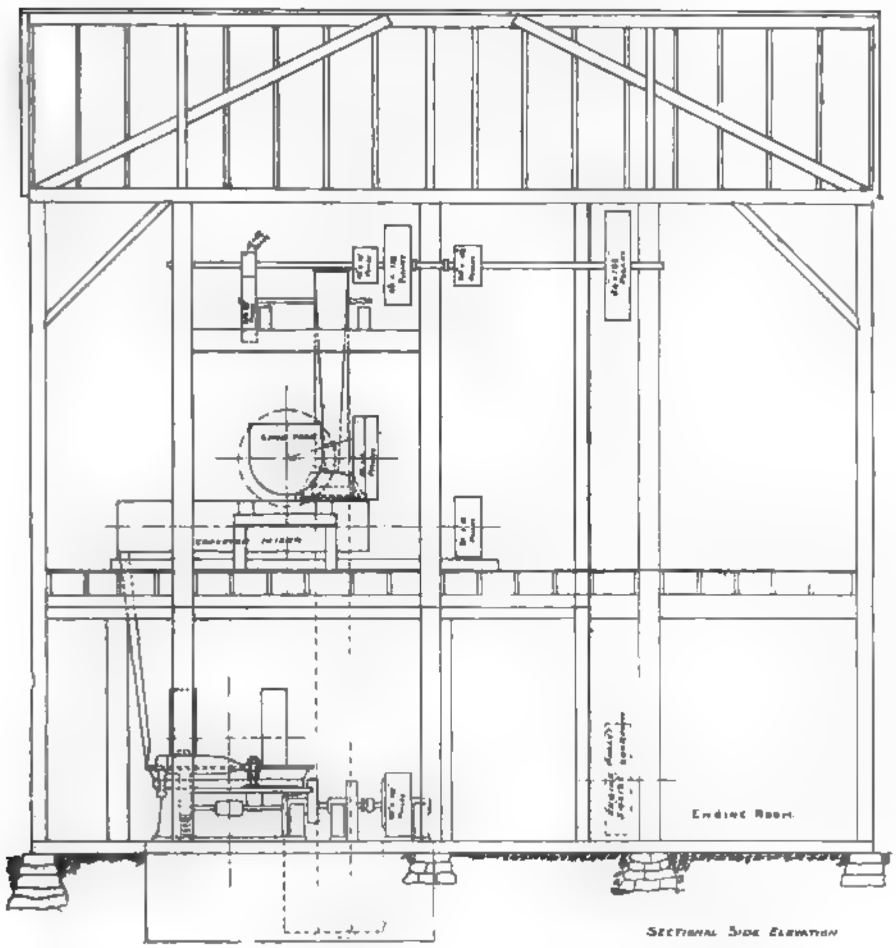


FIG. 41.—BRIQUETTING PLANT, BUILT BY CHISHOLM, BOYD & WHITE, CHICAGO.

the furnace. For this purpose 4 additional per cent. of lime is added to the dust in the form of lime milk. If the dust is too dry, some purple ore is also mixed with it. The whole is placed in a revolving mixing machine, whence it passes to a briquetting machine constructed by Messrs. Chisholm, Boyd & White, of Chicago, illustrated by Fig. 38. The mixing machine consists of a revolving shaft

with knives set at an angle and moving in an iron casing. The angle of the knives drives the mixed material forward towards the delivery end.

The briquetting machine consists of a pair of rollers running on a pan similar to that of a pug mill. At one side, the bottom of the pan is cut out to admit a perforated circular disc, whose centre is outside of the rim or curb of the mill, and the top surface of which is level with the pan track. A segment of the disc thus forms part of the track, over which the rollers travel. As the rollers with their accompanying scrapers pass over that section of the perforated disc which is within the pan, the perforations as they pass are subjected to repeated fillings and pressures as each of the ponderous rollers, with its peculiar twisting and grinding action, travels or rolls over them at the rate of 20 or more times per minute. As each successive pair of moulds passes out evenly filled with solid briquettes, the moulds stop directly under the plungers of a press, by which the finishing pressure is applied. The time for the action of the plungers is accurately determined by the movement of the disc. When pressed, the briquettes are pushed out of the perforations in the disc and dropped on to a conveying belt, which carries them to the drying furnace, where they remain for eight hours. This drying oven is heated by gas from the furnace smoke flue, whence it is drawn by an ordinary exhaust fan measuring 3 ft. in diameter. The plant, which is yet in its experimental stage, delivers 35 tons of briquettes per day of ten hours. Ten men are required to operate it.

Figs. 40 and 41 show a briquetting plant as described above, built by Messrs. Chisholm, Boyd & White. It is said that the cost of briquetting ore will vary from 4s. to 2s. 6d. per ton.

Slag.—Slag is either removed in metal-lined Weimer cars, or it is run into a granulating pit, whence it is removed by a grab bucket and loaded on railway cars.

The Weimer 200 cub. ft. capacity slag car, for example, is fitted with a dumping device worked by steam from the locomotive, to which the car is attached by means of a hose. All delay and difficulty in rapidly emptying the car is thereby fully overcome. The cast-iron linings for the slag cars are said to have an average life of nine months. The cost of maintenance of each car will prodably average £30 per year. Three cars suffice for a large furnace.

The system of granulating slag is coming more and more into favour. Outside the cast house is built a pit some 30 to 40 ft. deep, and from 20 to 30 ft. in diameter. A 4-in. water pipe is run into the same, the flow being regulated by a float operating a valve in the pipe. It is not necessary that the granulating water should be cold, but the tank must constantly be kept full. During the night, all the slag made is run into the water tank. During the day shift the slag is removed by means of a grab bucket suspended either from a trolley running on a stationary track, or from a rotating jib crane. The granulated slag forms a desirable raw material for cement. It is, however, mostly used for road metal. The railways often undertake to remove the slag free of charge, and to do all the shifting required in connection with the same.

The slag cement industry has been brought to a high state of

perfection, but has not attained such a magnitude as might have been expected. At the South Chicago Works, a large cement plant is connected with the blast furnace department.

There is also at the same place a plant for producing mineral wool, by blowing slag and steam through a pipe into a large collecting room. The rapid motion of the steam tears the liquid slag into fine threads, which are collected and used for insulating material and other purposes. Unfortunately, the slag wool is subject to changes under the influence of the atmosphere, which greatly reduce its value

Iron.—The iron is still, at many of the smaller furnaces, cast in sand in manner usual in England, but the cast beds in America are always covered. At other works cast-iron chills placed on the floor of the cast house are substituted for the sand moulds. Most of the modern furnaces, however, employ one form or another of the casting machine, or they are connected with steel works, which, during the week, receive all the iron in liquid state, after passing it through a mixer, where it is equalised and partly desulphurized. For carrying the metal from the blast furnaces to the steel works are used metal cars varying in capacity from 12 to 25 tons. The tipping gear for these ladles is often worked by an electric motor conveniently attached near the mixer.

The casting machine, as a problem, has been an attractive field for the inventor. The first practicable type was invented and patented by Mr. E. A. Uehling, late manager of the Sloss Iron Company, Birmingham, Ala. It consists of an endless chain of cast-iron moulds, the interiors of which are coated with a spray of lime milk. The endless chain of moulds measures from 108 to 130 ft. in length, and moves at such a pace that the iron remains in the moulds of the top strand for a period of about nine minutes. Arriving at the slightly elevated upper end of the chain, the pigs are dropped on to a conveyor, which descends into a water-filled tank, where the iron is cooled. It is then delivered on to wagons by gravity. This type of machine works well at many plants in America, but the cost of repairs of the numerous links, journals and supporting wheels, as well as of the iron moulds themselves, is a serious item.

Messrs. Heyl & Patterson have designed a modification of the Uehling machine. Each link of the chain in the Heyl & Patterson machine carries two moulds. The moulds are made of pressed steel plates, and are coated with smoke deposited as the moulds of the returning lower strand of the conveyor pass through a furnace fired with gas coal. The steel mould, after being filled with iron, descends into a water-filled tank, where the iron is cooled before it leaves the mould, and finally drops into the waiting railway car. Good results have also been obtained by this modification of the casting machine.

A third type in successful use is the *revolving machine of Davis*. This machine consists of a horizontal circular track about 80 ft. to 90 ft. in diameter. On this track travels a continuous line of carriages supporting the moulds. Each mould casting is made in the shape of a square bar, about 10 in. by 10 in. In two opposite surfaces of this bar are hollowed out the moulds for the metal. Journals or trunnions

mould at both ends, and the whole is frame of the carriage. The interior of lime milk. At a certain point along hydraulic hoist lifts and automatically manner that the drop of the liquid being filled, the mould continues passing wheel for about 270 degrees. Reaching fastened to the trunnion of the mould, the mould upside down, causing the new freshly-limed mould to the stream the ladle. In the meantime, the pig a second lower train of carriages which descends into a water tank, where Ascending from the water tank, the of their track where the exterior the interior. The flat tops of the slanting position, causing the pigs to below and alongside of the machine. very little trouble, and that moulds which is an important point. It has week.

me a necessity in America. Iron accepted by the trade, and is not furnace. Furnacemen do not more economical than even casting it does away with a very objection- labour, and it furnishes an iron in America will to-day raise as an of the machine-cast pig is affecting in this direction have proven cast and sand-cast pigs from the both as to strength, toughness and

and more generally bought and analysis, which, undoubtedly, is method.

casting machine, with its pertaining power plant and attendants, is more convenient way to handle foundry grades, is the pig- cast in sand, or if for the basic When the bed is cast, it is disturbed. It is then picked up to the pig-breaker.

in America is that invented by are installed at the Iroquois pig-breaker, as applied at these frame of steel in which rest two held suspended under the crane, successively breaks each pig in the and, when desired, breaks the sow

into suitable lengths. The pig-breaker works satisfactorily, and requires for its work the services of three men, viz., one breaker man, who also operates the crane from his station at the pig-breaker, one hooker-on, and one car shifter. The pig-breaker works cheaper than is possible with any now invented casting machine.

CHAPTER IX.

Blast Furnace Practice.

THE first and foremost article of creed of the American blast furnaceman is, that there is no better divisor for all fixed charges than a large output. The question of coke economy and duration of lining are given their due weight, but the American rightly claims that a blast furnace lining is good for a certain amount of wear, that is, a certain number of tons of iron, and that the sooner this quantity of iron is made, the better the furnace will pay for itself.

In regard to coke economy; this is, of course, desirable, but only so far as it does not seriously curtail the production of the furnace.

The second article of the furnaceman's creed is the necessity of uniformity of all conditions prevailing around the furnace. Uniform ore mixture, regular coke, constant temperatures, and the same volume of blast regardless of pressure, are the conditions aimed for.

He is greatly averse to changing his ore mixture, and, if compelled, will alter his burden only gradually. He analyses faithfully all the materials before they are permitted to go into the furnace, and maintains his slag at a proper percentage of bases with jealous carefulness. He is most particular always to have the furnace full up to a point within 3 ft., or at most 4 ft., below the bell, knowing that only so are the materials properly distributed.

Each furnace is, of course, blown separately and by its own engines.

As for stove temperature, the usual heat of the blast varies from 1,000 to 1,200 degrees Fahr. An extra stove is, however, always kept in reserve, so that, should the furnace slip, hotter blast can instantly be given. If, on the other hand, the furnace should show a tendency to hang, on account of being too hot, cold blast is immediately resorted to, rather than shaking the furnace. Ten to twenty minutes of cold blast generally brings the furnace down, provided it has been carefully watched and is promptly taken in hand.

Many furnacemen maintain that the amount of blast forced into a furnace has not yet reached its limit, though some of the larger furnaces now work under an average pressure of between 18 to 22 lbs., and receive from 50,000 to 70,000 cub. ft. of air per minute. A large

volume of blast, it is claimed, has the effect of making the furnace work uniformly all over, and prevents dirt troubles slips and irregularities.

Self-registering pyrometers, recording gauges and instruments, many of them by the Bristol Gauge Company, Waterbury, Con., are in

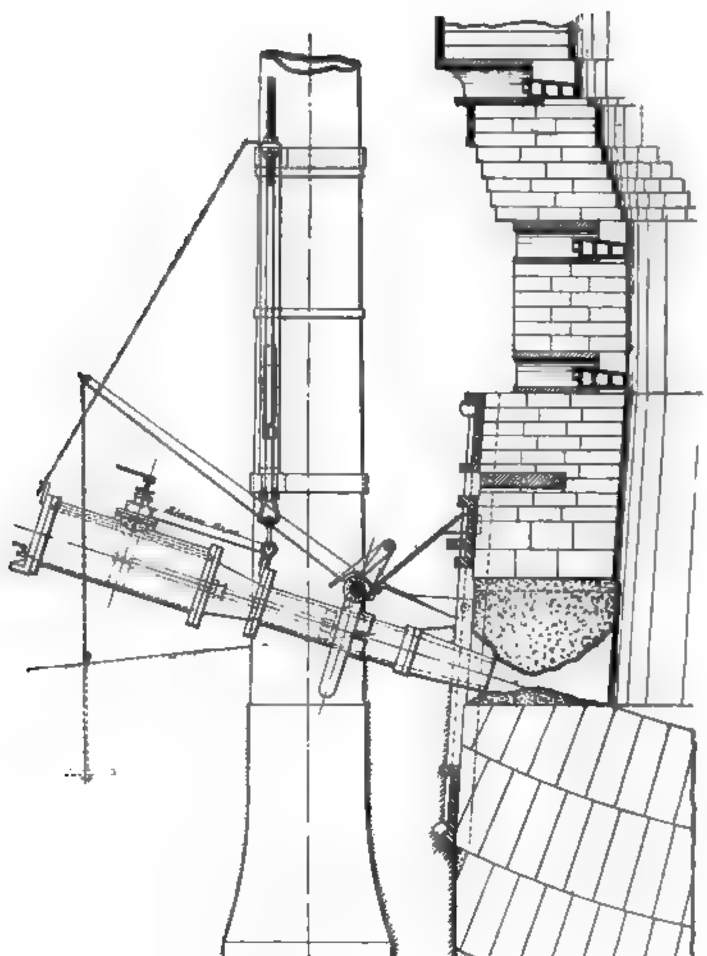


FIG. 42.—VAUGHEN'S TAP HOLE CLOSING MACHINE, IN POSITION READY FOR WORK.

general use, placing before the manager at all times graphical reports of cold blast pressure, back pressure in the furnace, temperature of blast from each stove, temperature of outgoing gases at the top of the furnace, steam pressure, volume of blast, number of skips hoisted, and height of stock line in the furnace.

The tuyeres of the modern furnace are set rather high, so that the

distance between the slag notch and the tuyeres varies from 3 to 4 ft. It is, therefore, practice to keep the slag notch closed up until the slag has risen nearly up to the tuyeres, when it is rapidly run out, or, as it is called, flushed.

The iron is cast without taking blast off the furnace. When the tap hole is to be closed, which is done by means of a "mud gun," shown by Fig. 41, the pressure is reduced to from 5 to 6 lbs. per sq. in., the gun doing its work against the flow of iron and slag. Thus from 40 to 60 minutes per day are saved, and the output from the furnace is correspondingly increased.

The tap hole closing machine, or "mud gun," invented by Samuel Vaughen, of Lorain, O., consists of a steam or air cylinder, generally 11 in. by 30 in., in which works a piston controlled by a plain slide valve. At the end of this cylinder is attached a clay cylinder about 7 in. by 30 in., ending in a tapering 5-in. nozzle. The whole gun is coupled to the steam or compressed air main, and suspended under a small swinging crane attached to the furnace column nearest the tap hole. Between the columns is supported at either side of the tap hole, a traverse bar, often made from a 3-in. double extra heavy pipe, fitted at the centre with two arms or prongs. As the gun is swung around and placed with the nozzle as deep as possible into the tapping hole, the bar with the prongs is, by means of a lever, turned around, so that the prongs engaging against protruding brackets on the gun force it against the aperture. The lever is then locked in position, holding the gun rigidly; steam or air is turned on, and the clay is forced into the tapping hole. If one cylinderful of clay does not suffice, the piston is drawn back, and additional clay charged and driven home, until the hole is securely closed.

The materials are placed in the furnace in heavy layers, it being maintained that the effect of the combustion of the coke is greater where larger quantities of the fuel are burnt together.

Dolomite and limestone are often mixed, in order to form a slag composed of a three-base silicate of lime, magnesia and alumina, instead of a two-base one of lime and alumina only; the reason being that, with the former, a more basic slag can be run and better control of sulphur obtained.

All weights are calculated in pounds only, not in tons, hundredweights, quarters, and pounds. By the former method time is saved and risk of error is reduced. The charging scales, whether fixed or travelling, are fitted with a number of weighbeams, generally six. The sliding weights are provided with locking screws. The beams are enclosed in a box and kept under lock and key. The operator has access only to the switch which couples the proper beam to the scale levers.

The method of filling adopted in starting a modern furnace, 100 ft. high, 22 ft. bosh, blown in during the summer of 1901, will be seen by the following schedule:—

(*a*) 13 tons of coke (below tuyeres).

(*b*) 23 chords of wood.

(*c*) 30 tons of coke (without limestone).

(*d*) 30 tons of coke, with sufficient limestone for flux (this layer reached 18 ft. above the tuyeres).

(*e*) Charges of: 4,000 lbs. coke;
„ 2,000 lbs. slag;
„ 350 lbs. limestone;
up to a point 31 ft. above tuyeres.

(*f*) Charges of: 4,000 lbs. coke;
„ 1,000 lbs. ore;
„ 1,000 lbs slag;
„ 350 lbs. limestone;
up to a level of 44 ft. above tuyeres.

(*g*) Charges of: 4,000 lbs. coke;
„ 2,000 lbs. ore;
„ 600 lbs. limestone;
up to a level of 57 ft. above tuyeres.

(*h*) Charges of: 4,000 lbs. coke;
„ 3,000 lbs. ore;
„ 800 lbs. limestone;
up to a level of 70 ft. above tuyeres.

(*k*) Then charges of: 4,000 lbs. coke;
„ 4,000 lbs. ore;
„ 1,150 lbs. limestone;
up to stock line.

The coke used was Connellsville. The ore, lumpy Lake ores. The stone, fairly pure calcite.

CHAPTER X.

Description of Some American Furnace Plants Visited.

Alice Furnace, Sharpesville.—This furnace is anything but modern, but serves as an example of what can be done with a modest plant, when the indispensable requisites—plenty of steam and plenty of blast are provided for.

This furnace, the lines of which are shown as No. 12 on Folding Plate No. 2, has a steel jacketed stack 70 ft. high, 14 ft. in the bosh, 10-ft. hearth, 7 ft. bell, 11-ft. stock line, and a capacity of about 8,000 cub. ft.

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The Erie Railway, on whose line the furnace is located, remove the slag, and do all shifting of incoming and outgoing materials.

The iron, which is cast in sand and chills in a small casting house holding only one cast at a time, averaged :—

Silicon	1 to $1\frac{1}{2}$	per cent.
Manganese ...	·80 „ 1	„
Phosphorus, about	·095	„

The blast temperature was maintained at 900 degrees Fahr.

The volume of air blown into the furnace was 28,500 cub. ft. per minute.

The blast pressure varied from 12 to 14 lbs.

The temperature of gases at top averaged 400 degrees Fahr.

The time during which the stock remained in the furnace averaged $5\frac{1}{4}$ hours.

During the last seven months, in a make of 50,000 tons, only 287 tons of iron had analysed above ·05 sulphur. The average product for the last six months had been 255 tons per day. The best month averaged 268 tons per day, and the best day's output reached was 301 tons (later 320 tons).

This record is unique for a small furnace. The ores are about as difficult to handle as it is possible to imagine. The stoves are poor, the filling is done by hand; the stock is lifted by a vertical hoist; the casting beds are insufficient—in short, there is nothing modern about the plant, except the methods employed by the capable young manager, Mr. E. H. Williams, to whom all credit is due.

The Carrie Plant, Carnegie Steel Company.—This plant consists of two older furnaces, Nos. 1 and 2, 90 ft. high, 19-ft. bosh, 12 ft. 6 in. hearth; and two new ultra modern stacks, Nos. 3 and 4, which at this writing hold the records of the world.* The new pair of furnaces, to the description of which I will confine myself, measure 100 ft. in height, 23-ft. bosh, 15-ft. hearth, 12-ft. bell, 17-ft. stock line, and are shown by Fig. 3, Plate No. 2. The height of the bosh is 16 ft. 2 in. above the twelve 6-in. tuyeres, which again are located 10 ft. 2 in. above the hearth level. The cubic capacity of each stack is 24,461 cub. ft. The furnaces are equipped with nine rows of cooling boxes, 24 boxes to the row. The shell is plate jacketed. The hearth is cased in a heavy plate jacket. The tuyeres are set in massive iron collars.

The furnace is equipped with a double skip hoist; the charging method has previously been described.

For each furnace there are four modified Massicks & Crooke's stoves, 21 ft. diameter, 100 ft. in height.

The steaming plant consists of 6,000-h.p. Cahall upright water-tube boilers, set in 24 units.

The engine power for the two furnaces consists of seven steeple cross-compound condensing engines, high pressure cylinder 45 in. diameter, low pressure cylinder 78 in. diameter, blowing tubs 78 in.

* Since this was written Ohio Steel Company No. 3 has taken precedence, producing 806 tons in one day of 24 hours.

diameter—all with 60-in. stroke. Two additional engines, making nine in all, are now under construction.

They are served by a central Weiss condenser, having two sets of air and circulating pumps.

For serving lifts, stove-valves, etc., there are two hydraulic pumps, 4 in. by 10 in., of Hall's patent type, working under a pressure of 450 lbs. per square inch.

The electric plant consists of three sets each of 500-h.p. compound condensing Westinghouse engines, 18¾-in. high pressure cylinder, 32½-in. low pressure cylinder, 36-in. stroke, and dynamos for 220 volts direct current.

The service water is furnished by three triple expansion Wilson-Snyder pumps, each having a capacity of 7,500,000 gallons per 24 hours.

The iron is going directly from the furnace across a fire and hot metal-proof steel bridge spanning the Monangahela River to the steel works at Homestead.

To take care of the sunday iron, are provided six single-strand Heyl & Patterson casting machines, having steel moulds pressed out of ⅜-in. plate.

Compressed air is furnished by one 10 in. by 10 in. duplex compound compressor built by the Rand Drill Company, of New York.

The ores employed are exclusively Lake ores; 40 per cent. of them are dust-fine Mesaba. The average mixture contains 52½ per cent. of iron.

Each charge consists of 14,000 lbs. of Connellsville coke, 5,500 lbs. limestone, and about 26,000 lbs. of ore.

The average coke consumption is given to be about 1,900 lbs. per ton of iron made—or 17 cwts.

The average temperature of the blast employed is 1,100 degs.

Blast pressure ranges from 20 to 22 lbs.

The limestone employed contains about—

	Per cent..
Lime...	50·50
Magnesia	.70
Silica...	5·00

The slag averages:—

	Per cent.
Lime and Magnesia	49 to 50
Silica	32 „ 34
Alumina	14 „ 16

The slag is handled in Weimer cars.

The weekly output, which later has been increased, was stated to have averaged about 4,000 tons per furnace. The best monthly record obtained up to October, 1901, was 35,000 tons for two furnaces or an average of 583 tons per furnace per day. Since then No. 3

furnace has turned out 790 tons of basic open-hearth iron in one single day.

These furnaces, Carrie Nos. 3 and 4, represent in their construction the exponent of all the experience acquired by the Carnegie Steel Company. The design, which was carried out by the present superintendent, Mr. G. K. Hamfeldt, was, I am told, the result of the co-operation between all the blast furnace experts in the company's service. The performance of the furnaces has proven that their experience has not been acquired in vain.

The Pioneer Furnaces of the Republic Iron and Steel Company at Thomas, near Birmingham, Alabama.—These furnaces are running mostly on foundry iron. They are located on a tract of land owned by the company, and comprising 4,000 acres of coal land, the seam being worked measuring 4½ ft.; 9,000 acres of ore land, the seam measuring 8 ft.; 2,500 acres of limestone, and ¼ sq. mile of dolomite. All these materials are assembled over the company's private railway line.

The plant consists of three stacks, Nos. 1 and 2 being 75 ft. high, 18 ft. in the bosh, 11 ft. 6 in. in the hearth, bells 9 ft. diameter; number of tuyeres, 12 and 16 respectively; height of bosh, 14 and 11 ft. respectively; height of tuyeres above hearth, 6 ft. No. 3 stack, which is shown by Fig. 11, Plate No. 2, measures 85 ft. in height, 18 ft. 6 in. in the bosh, 12 ft. 6 in. hearth, height of bosh above tuyeres, 11 ft., height of hearth, 8 ft. Stock line is 13 ft. 3 in. in diameter, bell 9 ft. There are 12 6-in. tuyeres. Just above the bosh there is a cylindrical section of the furnace 9 ft. high. This furnace was not in operation at the time of my visit, but is built with unusual strength and considerable expenditure of money.

No. 3 furnace is equipped with four 22 ft. by 80 ft. Massicks & Crooke's stoves.

3,000-h.p. Wheeler vertical water-tube boilers.

Two steeple cross-compound engines, built by the Rarig Engine Company, of Columbus, O., having 42-in. diameter high pressure cylinder, 80-in. low power cylinder, and 84-in. blowing tubs, all with a stroke of 60 in.

To the engines are attached a Wheeler condenser, and a Cochrane feed-water heater of 2,000-h.p.

The service water is delivered from a standpipe 125 ft. by 8 ft.

The hoist of the older furnaces, Nos. 1 and 2, has been described previously in Chapter VII.

For No. 3 furnace is used a hoist carrying a large cylinder which will contain an entire charge. This cylinder, supported on a car, descends into a pit at the foot of the hoist incline. The electric larries, travelling on narrow-gauge tracks laid on ground level, collect the charge from the various bins and coke ovens, and deliver it into the depressed cylindrical skip, which then ascends to the top, emptying the charge into the hopper.

The iron is cast in sand in order to preserve the fracture which is required for iron to be exported.

Adjacent to the furnace plant are 910 beehive coke ovens

measuring 12 ft. diameter by 7 ft. in height, whence the coke is brought directly to the furnace. The coke is partly from washed and partly from unwashed coal. It analyses as follows:—

	Coke from Washed Coal.	Coke from Unwashed Coal.
Carbon	82·81	82·30
Sulphur	·96	1·63
Ash	14·11	15·80

The consumption of this coke per ton of iron is from 30 to 31 cwts.

The ore mixture consists of soft-red and hard-red ore, brown ore and mill cinder.

The average analyses of these ores have already been given on page 405.

It requires 50 cwts. of ore to make one ton of iron.

The slag produced averages:—

Silica	32·30	per cent.
Lime	45·68	„
Magnesia ..	5·00	„
Alumina ...	15·20	„

The foundry iron, which represents over 75 per cent. of the make of the works, averages:—

	No. 1.	Soft.
Silicon	2·5 to 2·63	3·38
Sulphur	·022 „ ·05	·029
Manganese	·51	·47
Combined Carbon	·13	·10
Graphitic Carbon	3·70	3·75
Phosphorus	·86	·70

The average make for Nos. 1 and 2 furnaces for the month of March, 1900, was given as 209 tons per furnace per day.

The plant is considered the most successful in the south, both economically and technically.

Wharton Furnace, Port Oram, N.J. (recent).—The discovery of a great body of magnetic ore in the Hibernia mines in Northern New Jersey caused the construction at Port Oram, in 1901, of a large modern blast furnace, which is one of the best built and best designed blast furnaces in the United States.

The furnace stack, the lines of which are shown by Fig. 6, Plate No. 2 (same as Warwick), measures 100 ft. in height, 21 ft. bosh diameter, 14 ft. diameter of hearth; incline of bosh walls 72 degrees,

height of hearth 7 ft.; height of bosh 15 ft. above tuyeres, diameter of bell 11 ft.; diameter of stock line 15 ft. The furnace is blown by 16 6-in. tuyeres.

The furnace equipment consists of four 22 ft. by 100 ft. Cowper-Roberts stoves;

2,500-h.p. Stirling boilers;

Two pairs horizontal tandem independent compound Southwark engines, 44-in. high pressure cylinder, 84-in. low pressure cylinder, 84-in. blowing tubs—all 60-in. stroke, with a Weiss counter-current condenser.

The water supply is obtained from two 5,000,000 gallons Laidlaw, Dunn & Gordon Company's three-cylinder compound pumps forcing the water into a standpipe.

The electric plant consists of two 50-k.w. sets of direct-coupled dynamos running at a tension of 220 volts.

Attached to the furnace is a Uehling casting machine.

The smoke stack is 225 ft. high by 14 ft. inside diameter.

At the time of my visit, this furnace was running on a mixture of three quarters Hibernia and one quarter Lake Superior ore.

30 cwts. ore, half calcined, half raw, and one ton of coke, were used to produce one ton of pig-iron.

Hibernia ore is a magnetite analysing—

Iron ...	...	57 per cent.
Silica ...	...	12 „
Sulphur	...	·02 „
Phosphorus	...	·3 „
Lime ...	...	3·0 „
Manganese	...	·8 „

This ore is assorted at the mine. The low-grade lumps are crushed to 2-in. mesh, and sent over a rough cobbling separator. It is proposed still further to crush the middlings and tailings from this separator, to pass them over a second fine separator of the Ball & Norton patent type, and afterwards to briquette the concentrates. The ore on arrival at the furnace is roasted in 36 modified Davis-Colby kilns, having a capacity of 1,500 tons per day. In these kilns some carbonic acid water and the trace of sulphur are at least partly removed, but, what is more important, the peroxide of the magnetite is partly transformed into sesquioxide, whereby the ore is made more easily reducible. When the furnace is not running, gas for the roasting kilns is supplied by two Talbot producers.

The furnace produces a high-grade foundry iron, and is of particular interest because of its location within 50 miles of New York Harbour. Having its own ore of excellent quality, it can deliver foundry iron in New York *cheaper than any other plant in the United States*, and its product may, therefore, be heard of in the English markets.

North Lebanon Furnace of the Pennsylvania Steel Company, Lebanon, Pa.—This furnace is constructed closely on the same lines as the Port Oram furnace. Its lines are shown by Fig. 7, Plate No. 2. It is equipped with:—

Four Massicks & Crooke's stoves, 22 ft. diameter, 100 ft. high.

2,000-h.p. Babcock & Wilcox boilers.

Two pairs vertical independent compound quarter-crank engines running from 50 to 70 revolutions. The cylinders measure 42-in. high pressure cylinder, 80-in. low pressure cylinder, 84-in. blowing tubs, all 60-in. stroke.

The furnace is blown by sixteen 5-in. copper tuyeres.

40,000 cubic ft. of air per minute are blown into the furnace under a pressure of from 11 to 14 lbs.

This furnace averages from 200 to 250 tons per day, the highest output reached being 301 tons for a single day.

The fuel is Connellsville coke, running :—

Carbon ...	... 85	per cent.
Ash ...	... 10 to 11	„
Sulphur ...	... ·90	„
Phosphorus	... ·012	„

The limestone used for flux contains :—

Lime ...	 54	per cent.
Magnesia	... ·7	„
Silica ...	... ... ·85	„
Alumina	... ... ·4	„

The ore is exclusively Cornwall magnetite, partly roasted, partly raw. The raw ore analyses :—

Iron ...	... ... 45 to 46·00	per cent.
Silica ...	... ... 16·90	„
Alumina	... ... 4·25	„
Lime ...	... ... 3·92	„
Magnesia	... ... 7·21	„
Sulphur	... ... ·82	„
Copper...	... ... ·56	„
Phosphorus	... ... ·02	„

The resulting iron runs :—

Silicon about ...	... ... 2·5	per cent.
Sulphur about	... ... ·04	„

The slag contains :—

Silica ...	... ... 30·5	per cent.
Alumina	... ... 12·5	„
Lime ...	... ... 40·0	„
Magnesia	... ... 9·0	„

45 cwts. of ore are used to make one ton of iron. Considering the leanness of the ore, these are excellent results.

The Bessemer iron produced, which is mostly turned into rails, is as cheap as any manufactured in the United States.

The roasting kilns employed at this furnace, as well as at Port Oram, are worthy of description. A schematic cross section of the

same is shown by Fig. 43. They consist of two parallel rows of kilns measuring at the top 6 ft. in length by 2 ft. in width. Over each row of these kilns is a railway track, on which run trucks loaded with raw ore travel. The kilns are 20 ft. deep, and widen towards the bottom to 3 ft. Along one side of the kilns runs a combustion chamber fired by waste gas from the furnace. On the

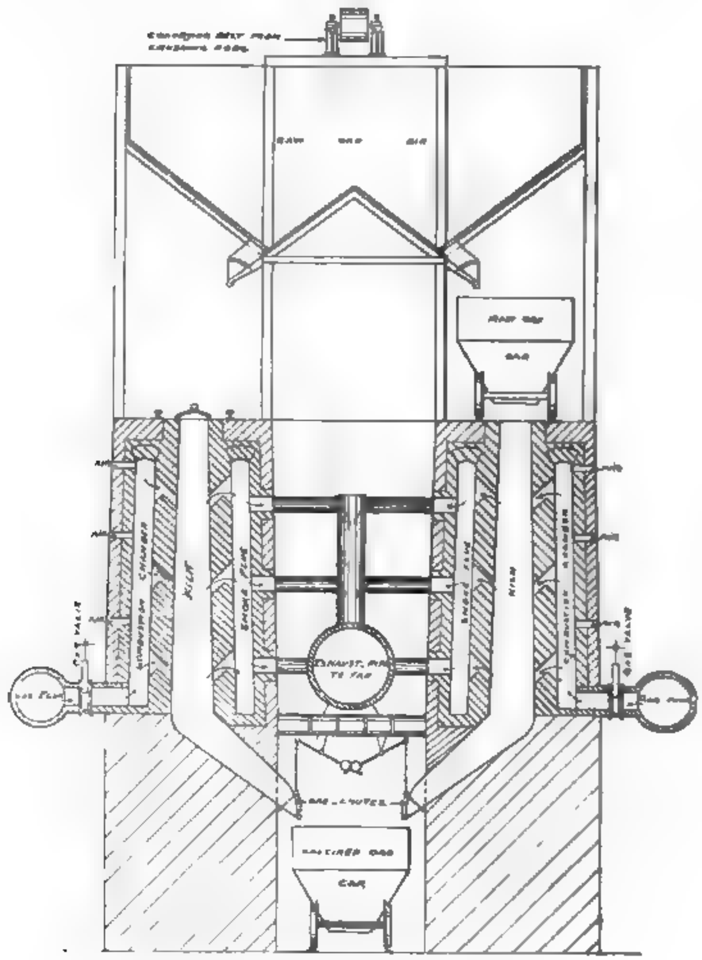

FIG. 43. MODIFIED DAVIS COLBY ROASTING KILN FOR ROASTING ORE. (SKETCHED FROM NOTES MADE DURING VISIT.)

opposite side of the kiln runs a smoke flue. The numerous openings or slits through the brick walls of the kilns connecting it with both the combustion chamber and the smoke flue are built in such a manner that any dust gathering in the slits will return by gravity into the kiln. The smoke flue connects with a collecting pipe leading to an exhaust fan. The ore arrives from the Cornwall mines in standard railway cars; it is dropped from the cars into a pair of

36 in. by 36 in. Edison crushing rolls, and is then lifted to a hopper placed above the charging tracks on top of the kilns. From this hopper, the automatic charging trucks built by Messrs. C. W. Hunt & Company, New York, are loaded by gravity. The truck is run down to the kilns which are to be charged, where the bottom of the truck is dropped, the ore descending into the kiln, while the empty truck automatically returns to the storage bin. When the kiln is charged, the top is closed, and the valves communicating with the gas main and the combustion chamber are opened. Sufficient air to burn the gas is admitted to the combustion chamber. The products of combustion passing through the slits into the roasting kiln, penetrate the column of ore, and depart through the slits in the opposite wall into the smoke flue, whence they are drawn by the exhaust fan and delivered into the chimney. When the ore is calcined, the door at the bottom of the kiln is opened, and the ore falls by gravity into a car running on the ground level between the two rows of kilns. The 32 kilns are served by six men on each turn—two top fillers, two crusher men, one ore drawer and one man unloading ore from railway cars.

Lackawanna Steel Company, Buffalo.—At this place is now being constructed one of the largest iron and steel plants in the world. Though the plant is as yet far from completion, enough has been done to impress the visitor most forcibly with the boldness of the design and the immensity of the undertaking. The Lackawanna Company, who hitherto have successfully operated what in most countries would be considered an extra modern rail plant, with steel works and furnaces, at Scranton, Pa., found that the cost of railway transport for Lake ore and for marketing their product was placing them at a disadvantage. They therefore secured a level tract of land measuring 1 mile by 3½ miles, at Stony Point on the shore of Lake Erie, 9 miles south of Buffalo. This plot offers rock foundation at a depth of 80 ft., a deep water front accessible for the largest Lake steamers, abundant and pure water supply from the Lake, direct connection with 27 large railway systems, navigation over the whole system of the Great Lakes, and through the Welland Canal, with 14 ft. of water, and St. Lawrence River to the ocean and the world at large, and finally through the Erie Canal, having 10 ft. of water, directly to the Hudson River and New York. It would be difficult to find a place better supplied with lines of communication. The company own their own mines in the Lake Superior district, as well as the Port Henry mines in Northern New York and large coal territories in Western Pennsylvania. Besides, they control a considerable share of the Cornwall ore mountain in Pennsylvania, and several furnaces located close to the same.

It is their intention to wash and crush the coal at the mines in Pennsylvania, to dry it in hot air storage houses having concrete hopper-shaped floors. The coal, when dry, will be carried to the Buffalo plant, where it will be unloaded into a receiving hopper. From this hopper, it will be shot by gravity into a hydraulic press, in which it will be shaped into blocks, each block making the

charge for one by-product coke oven. The plant is laid out for 1,000 of these ovens, but at present only 564 are being built and provided with a complete plant for saving by-products. The coal will be charged into coke ovens on a peel attached to the coke pusher. The pusher will deliver the ready coke on to an apron or crate about 25 ft. by 10 ft. by 4 ft., which will be lifted whole on to a truck, and brought to the blast furnace hoists. The charging of the furnace will be arranged so that one coke oven charge will form a unit of fuel.

A large harbour, 200 ft. wide, is being dug out between the

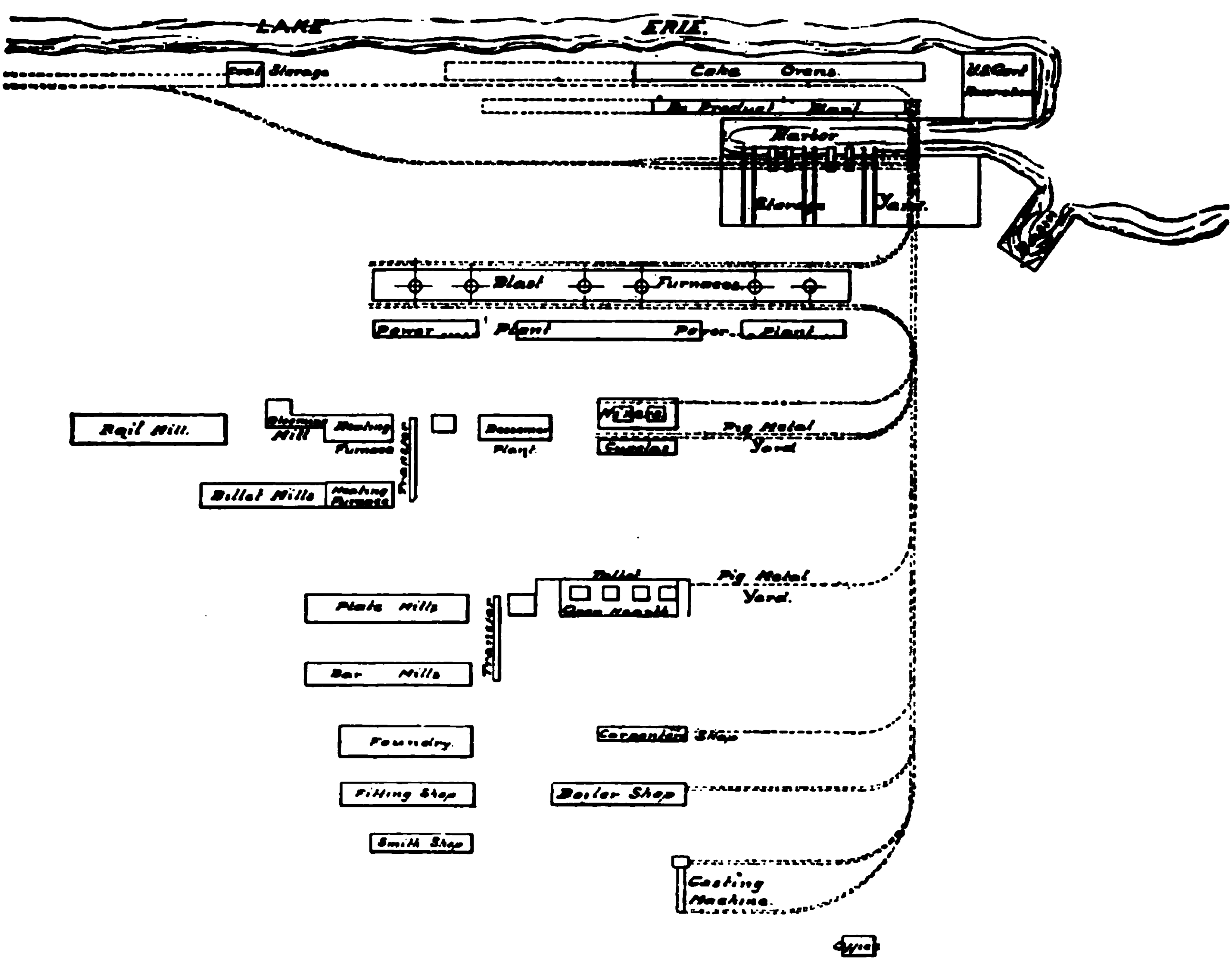

FIG. 44.—SKETCH FROM MEMORY OF THE PLANS OF THE LACKAWANNA STEEL COMPANY'S NEW PLANT, UNDER CONSTRUCTION AT STONY POINT, NEAR BUFFALO, N.Y.

coke ovens and the furnaces. The coke will be carried through a tunnel under the harbour to the furnace yard. The ore ships arriving in the harbour will be served by four Hulett automatic unloaders carrying 10-ton grab buckets, and by six Brown bridge tramways arranged along the harbour and covering the storage yard. The same harbour will also serve for shipping the product of the plant.

The plant is laid out for six furnaces, of which four are to be the largest in the world. Their proposed lines are shown by Fig. 1, Plate No. 2. Two large new stacks are now under construction, while

two of the Scranton furnaces have been torn down and are now being re-erected at the Buffalo plant.

The large furnaces will be the first in the United States to be driven exclusively by gas engines. These engines will have single gas cylinders, and are being constructed in the United States. An output of 800 tons per day from each furnace is expected. Connected with the furnaces, there will be Heyl & Patterson casting machines and one 300-ton mixer.

Though it is a digression from my subject, it may be permitted briefly to describe the plant being constructed, as it was explained to me by Mr. Wehrum, general manager of the Lackawanna Company. A diagram of the plant is drawn from memory, as shown by Fig. 43. The plan does not even pretend to be correct as to dimensions, or complete as to railway tracks or buildings. It is merely intended to show the vastness of the undertaking and the number and variety of the departments included, even before the finishing departments are even mapped out.

It covers as far as it is now planned, a territory 1½ miles in length, of three-quarters of a mile in width, leaving an unused plot for extensions and finishing departments of two miles in length and three-quarters of a mile in width. Part of the iron taken from the blast furnace will be delivered into the 300-ton mixer. From the mixer it will be passed on to a Bessemer plant of four converters. The converters will also be supplied with iron shipped cold from the Cornwall furnaces and remelted in cupolas. The steel ingots are handled by two pairs of ingot strippers, and are forwarded to two blooming mills, and thence to the rail mill now being transferred from Scranton. Another branch of the works will deliver steel from the Bessemer plant through two tandem blooming mills to a three-high billet mill.

On a parallel line with this first steel plant will be placed a Talbot open-hearth plant consisting of four 200-ton furnaces, followed by a reversing plate mill of English style with separate finishing rolls. A transfer arrangement between the open-hearth steel works and the plate mill will deliver steel ingots to universal plate, bar and shape mills standing alongside of the reversing plate mills.

In a line parallel with these mills follow extensive shops, foundries, blacksmiths' shops, machine shops, etc., well built with steel frames, brick filling and slate roofs. Overlooking the whole is placed a magnificent general office building in colonial style. Never in the history of iron and steel has so large and many-sided a plant been planned and constructed simultaneously in all its departments.

CHAPTER XI.

Direction, Management and Labour.

In America, the personal factor in iron making is recognised to be fully as important as that of plant. It is not the guns which win the battle, but the men who stand behind them. A good weapon, poorly aimed, is not dangerous, but neither will it do to arm good

fighters with obsolete guns. In the above report I have tried to show that the guns—that is, the plants—are splendidly and powerfully equipped, that raw materials are plentiful and good, and that the system of transportation and handling is unexcelled. In this chapter, I wish to speak of the men as I have learned to know them during 20 years of association.

Directors.—The directors of iron and steel and kindred enterprises are, as in other countries, selected from two classes: partly from amongst the capitalists interested in the business, and partly from the ranks of specialists who have worked and risen in the service of the industry, and to whom its management is confided.

The individuals are generally selected for their personal business capacity, special knowledge, energy, vigour and reputation. The younger men, as a rule, having more enterprise and endurance than those more advanced in years, are found on the boards in America in a greater percentage than in any other country that I know of.

I have often heard it erroneously stated that the Americans worship dollars. This is not so, because a rich man as such is not greatly esteemed. What the American admires and honours is the ability to do; that capacity in a man, through his own sagacity, nerve, enterprise and skill to create and employ a fortune. Nobody in America seems to feel above his work or degraded by it. As it is done, and as is the result obtained, so is the man esteemed by his fellow-men, and such is the place he will make for himself in his community or in his country. Everybody works, and works for the sake of work; and thus there has been produced in America in the short space of one generation an industrial potentiality, which is more wonderful and more to be feared than the works and plants which these same workers have created.

Nowhere is the struggling youth more kindly encouraged, more readily trusted, more generously aided, more gladly made place for, than in America, and when I say this I speak from personal experience, and with gratitude in my heart towards many of those busy and keen, but also generous and broad-minded American men of affairs.

"Why," said a prominent and successful man of the older generation when discussing life in America, "Here you have to be in business if you want to be happy. If you quit business you have no company." A younger man present, who has made his own millions, heartily endorsed the speaker; and it must not be forgotten that business in America means WORK, and that both these successful men knew this from their own experience.

During my late visit, one of the most successful American iron and steel works owners, the Nestor of his class, and a prominent man in politics and public affairs, said, when talking of his life work: "I can honestly say that I have never worked to make money for the sake of money. I have always tried to do my best to succeed in what I undertook. My pleasure has been to organise and develop, my greatest enjoyment to watch the growth and prosperity of my work. The money part then took care of itself." And yet this man has not been a slave of his work. His life has been a rich and generous one, brought into intimate contact with the great men and

great events of his time, varied by travel, politics and literary occupations; but first and dearest to him is his life work, those great and commanding works, and to them he gives to-day his time and brains as he did in his youth.

Though, as I have said, many of the directors are specialists, men who minutely understand their business, their good judgment and keen sense of proportion makes them trust all details to their managers. Another characteristic is their patience in awaiting results, which often turns a seeming failure into success. Though patient, they are, however, the most energetic of men, ready to overcome obstacles and to revolutionise existing conditions, instead of bending and submitting to them. In this, they are, of course, greatly aided by the vastness of their country, its enormous resources, and the comparative freedom from antiquated institutions and accumulated traditions, which at every step hamper progress in older countries.

In the south, conditions of ownership and direction have hitherto been exceptional. The southern iron industry began with the discovery and bringing to notice of the ore and coal deposits of Virginia, Tennessee, and especially Alabama during the years 1878 to 1882. At that time the rich southern land had hardly begun to recuperate from the effects of the great Civil War, which has robbed it of its best men, its labour and its capital. Fifteen years had not sufficed to heal the grievous wounds, or to create capital for new enterprises. When the discoveries of coal and iron ore were made, it was, therefore, in the north that the money was found for exploiting them. The southern men realised the enormous importance of securing industries, but also lacked experience of the means required. Estimates were procured from contractors for furnace plants of the flimsiest description. On the basis of these, glowing prospectuses were drawn up, proving that small investments would reap golden harvests. The moderate sums considered sufficient were subscribed by northern capitalists, who were attracted by the hope of profit, but as a rule knew nothing of the business they were embarking in. With poorly built plants, insufficient working capital, and new and unknown conditions to meet, the iron industry of the south was started in a country without any market for iron. The boom broke as suddenly as it had been started. Stockholders and directors forgot all about the really substantial foundation of handy, if not high class, raw materials. The necessary funds to develop and reconstruct were refused by men smarting under the disappointment of the non-appearance of dividends. The one plant after the other was put out of blast, towns were abandoned, trees grew up between the rails of the mineral railways; decay and hopelessness succeeded the feeling of extreme buoyancy.

One of the leading men in the southern iron world said, when speaking of the past: "One, and the principal reason, why the iron industry of the south has not been successful is, that the works have been owned in the north, and that the owners have not personally devoted their time to the business, or even understood its requirements."

In recent years a reconstruction has taken place. Specialists have

taken the helm. Money is more plentiful. The southern country has grown in wealth and industries, and the products have become more diversified. The promise for the future is, therefore, bright. Southern steel and southern iron are becoming a factor in the iron business of the outside world, which it would be most unwise to neglect.

Managers.—The sagacity of the directors is especially noticeable in their selection of managers. Mr. Charles M. Schwab said, during an interview, while speaking of the great corporation of which he is the head: "We pay high salaries because it is economy to do so. A good income attracts first-class men, and such a man will earn his salary over and over again."

Another prominent ironmaster said: "We want a manager who not only keeps our works going, looks after men and plant, and repeats to-morrow what he did to-day, and next year what he did during the last; we demand of our manager that he looks ahead, watches and keeps us informed of the trend of the times, and the progress daily making in our industry; that he devises means and methods to meet altered conditions, and to keep our business in the front rank. It is not enough that he works up to the level of others. He must constantly endeavour to do a little better, accomplish a little more, save a trifle here, improve a detail there. As for the blast furnace manager who has not learnt more during the time his furnace has been working than to put it into blast again, after repairing it on the same lines as last time, without seeing his way to improve, to strengthen, and to make more effective his furnace; we have no use for that class of men."

"We want young men who have not had time to wear themselves into a groove," said another leader, "young college men preferably, who are not too genteel to work their way up from the bottom; or we like young fellows who, without educational opportunities, have shown the spirit and ability to acquire an education while working in shop or office. When a college graduate, who shows that he has the right stuff in him, reaches the age of 25 to 30 years, he is ready for a position of trust. When men get older they may have acquired a wider experience, and, therefore, become more valuable as specialists, but for managers and executives we select young men with brains and education."

American methods are apt to develop such young men. Boys graduate from the High School, which is the highest grade of the American public school, at the age of about 17 years, with a very fair general education. A year or two spent in practical work, and another half-year in a preparatory course, and the young man is ready to enter on his four years of university training. Excellent universities and colleges abound, having a curriculum specially adapted for developing practical usefulness in after life. The ample pecuniary endowment of many of these colleges puts them in a position to furnish the most excellent teachers, apparatus and laboratories, and when a young engineer at the age of about 22 to 23 enters on his profession, he has at least learned how to learn, how to teach himself, how to

reason logically, and he has acquired that power and broadness of view which knowledge gives. Whether these young men in after life keep up the details of their school knowledge or not, they will still have that education which Americans define as that "something which a man retains when he has forgotten all that he has once learned at school." What more he needs of practical experience to fit him for a position in his chosen branch, he now acquires with great rapidity, and if he has the common sense, brains and will power, which no amount of schooling can give him, he is, before long, found out and placed at his proper level.

Of the 21 blast furnace works which I visited, 18 were managed by college graduates, the majority of whom were young men.

While it, undoubtedly, is an error to permit theory to be your master, instead of the most valuable servant of your common sense it is, however, undeniable, that the exactitude and analytical habits of a scientifically trained manager exercise a valuable influence on the operation of the works confided to his care.

The laboratory in the hands of a young man equipped and aspiring one day to step into the manager's place, furnishes valuable and never neglected information. The phenomena of manufacture are carefully noted, studied and explained for future guidance and reference. No particle of material is permitted to pass into or leave the furnace without being analysed, and the analyses are scrutinised and observed.

Not less important is the draughting office, and how systematically and completely its work is done is best realised by quoting the legend often found printed on American shop drawings: "Stick to measurements, add nothing, change nothing, report all errors." At the first glance, it may seem that this is carrying system too far, but it is money well spent in the office, and over and over again saved in the shop. At the same time, this system gives valuable and thorough training to the young who are getting themselves ready for their life work.

I do not wish to convey the idea that every man on the board of an American iron company, or every man who manages an American furnace is of the type which I have sketched, but I have tried to hint at the kind of men—the majority by a goodly margin—against whom the European ironmasters, when the next general depression arrives, must contend in the struggle for markets and profit.

Amongst American managers is often found a reminder of the college spirit and comradeship of youth. Each man feels attracted to his fellows working in the same field. They meet, exchange views to mutual benefit, and are always ready either to ask or to give each other assistance or information. To this fellow feeling contributes greatly the congenial and hearty tone prevailing at the meetings of the American Engineering Societies first, and last the American Institute of Mining Engineers. Few of us who have been privileged to meet and know the men who are the leaders of this society but can thank them for many a friendship and many a hint which has helped to make our professional life more easy or more profitable. As an example of this spirit it happened, during my

recent stay in America, that an isolated, large modern blast furnace, through a serious breakdown, came near being chilled. There were only two men to divide the disheartening work of trying to save the furnace, the manager and his assistant. Both soon became thoroughly worn out, and their bodily fatigue was reacting on their spirits. One blustery afternoon, two young blast furnace managers, both with fine reputations and excellent records, appeared at the furnace, having come from a distance, travelling bag with working outfit in hand. "Say, old man; we heard you had trouble, and we know you are short-handed; we came up to see if we could not take shifts and do what we can to help pull you through." And be it said to the honour of the manager in trouble, he was not too vain to accept the offered assistance which his neighbours had shown the goodwill and faith in his broadmindedness to venture to offer.

Talking to a very able young manager about giving information regarding working conditions and results, he said: "It would be stupid of me to refuse a colleague information. I am now doing as well as I know how. If anyone else by the help of the knowledge of what I have accomplished, can improve on it, the benefit is mine, and I will improve with him. No one man can know it all."

Labour.—In regard to American labour, President Roosevelt expresses himself in his recent message to the United States Congress, in the following terms: "American wage-workers work with their heads as well as their hands. Moreover, they take a keen pride in what they are doing; so that, independent of the reward, they wish to turn out a perfect job. This is the great secret of our success in competition with the labour of foreign countries."

As far as the writer can judge from his own experience in the United States, as well as in Great Britain, in Sweden, and on the European Continent, the President's statement is unquestionably correct. But the American workman, often brought up in a self-respecting home of comparative comfort, educated in a good school, having breathed from childhood that atmosphere of independence and self-reliance which is the unique blessing of America, and having been taught that he is an equal in rights and opportunities with any other man in the land, is not, generally speaking, going to rest content to be a hewer of wood or a drawer of water. He can think, therefore he soon devises easier and more attractive ways of earning his bread. His ingenuity, goodwill and application fit him for better duties. Thus it is that around American blast furnaces, the American is found in a very decided minority. He may be a foreman, master mechanic, blast engineer, locomotive driver or stove tender, but he will not work 84 hours per week shovelling ore or wheeling scrap. For these duties are employed in the south the negroes, and at the northern furnaces immigrants, mostly Irish, Slavs or Italians. The material available in America for training blast furnace hands is, therefore, not as good as is found in England, Germany or Sweden. The language is a first and not a mean difficulty. This overcome there is the ignorance and awkwardness of many of the men.

Here the American manager shows his great ability by getting

unparalleled results with an anything but first-class crew. By pitting different nationalities against one another a wholesome rivalry is set up. The successful or deserving are encouraged and promoted. The laggards and incompetents are soon got rid of. The men are made to feel that nothing but their own ability and efficiency limits their progress and advancement, no matter what their nationality or origin may be. The man who simply does what he is told as long as he is watched, and leaves at the first sound of the whistle, whether his work be done or not, is sure before long to be replaced by another man who thinks more of his job and of his future than of the hands of the clock.

Labour Unions practising the policy of impeding progress and curtailing output, are not tolerated in the American blast furnace works. As far as the writer knows, such an organisation is to be found in only one rather unimportant plant located in the centre of a great city, and the experience with the union at this place has been such as to make owners and managers resolutely set their face against all attempts to introduce similar societies at their works. Agitation amongst fellow-workers or expressed leanings towards unionism are, therefore, considered good reasons for discharge as soon as the opportunity offers. It is not the men themselves that the manufacturers fear, but the unscrupulous agitators who, with a despotism never equalled by employers, domineer over the men, and who, without the knowledge, judgment or ability to conduct a large business, presume to dictate how such an affair shall be managed. With unions such as are known in some other lands, I venture the emphatic statement that blast furnace work as successfully carried out to-day in America would be impossible.

Work around the blast furnace is carried on in two shifts of 12 hours each, or in some cases by 11 hours day shift and 13 hours night shift. The bulk of the heavy drudgery has been obviated by the use of machinery. There is no pig-lifting, no hand shovelling of stock, no hauling of charging barrows. All the tedious clay work around the hearth, and incessant changing of tuyeres, is done away with. But after all this is done, blast furnace work is, and will remain, a hard occupation, requiring endurance and muscular strength. Of the crude immigrants who arrive, and are willing to take it up, only a moderate percentage have the necessary strength and intelligence to fit them for the work. Being without friends or home, they feel, however, that on their own efforts depends their existence, and one must do them the justice to say that they work hard and well and require little or no driving. The percentage of time lost is very small. Any man who shows himself irregular or indifferent is promptly removed.

At some furnaces in the south, only three men on each shift are whites. The opinion regarding negroes as blast furnace workers varies. But it is generally recognised that the blacks have little realisation of the importance of regularity of attendance. They require to be continually supervised and cajoled, rather than driven. In spite of everything, they are apt to leave their work if a circus or other popular amusement should arrive in the neighbourhood where they

ıe somewhat lower rates paid to the coloured workmen :, therefore, more than neutralised by their unreliability and other lings. There are, however, numerous exceptions to this rule, and have personally known and supervised hundreds of coloured iron ·rkers capable of competing with white labour in any country. ıe hot climate of the south would also make it difficult for white men perform such heavy manual labour, so that, good or bad, the iron asters are dependent on the coloured population for this class of ork.

At one particular furnace which I visited, the manager expressed imself perfectly satisfied with his coloured workmen. At no time ıring the past two years had he been short of labour, though he ept only four spare men around the furnace plant.

The cheapest and best blast furnace labour is found in Eastern ennsylvania, where the crews are recruited from the native Penn-lvania Dutch. These men are regular and saving in their habits, nd though their pay is not high, many of them own their own homes ınd feel more or less identified with their towns and the business interest for which they are working. Amongst these men, there is hardly ever the question of a strike, dictation to their masters, curtailing output, or any other of the evils with which the labour unions have made us familiar. Without being particularly bright or of superior intelligence, these men are, therefore, very valuable as blast urnace workers.

Below will be found a table of rates paid in October, 1901, at furnaces in different sections of America, and also, for comparison, giving the rates paid in October, 1901, at furnaces in the West Cumberland and Middlesbrough districts of England. The figures have been given me by the managers of the different works. The rates are all given per 12 hours, which means 1 shift in America or 1½ shifts in England. Where prices have been left out, information has not been received in regard to them. It will be seen that, hour for hour, there is little difference between American and British wages, but when the output of the furnace is taken into consideration, the American masters have a great advantage :—

COMPARATIVE BLAST FURNACE WAGES IN UNITED STATES AND IN ENGLAND, OCTOBER, 1901.

Location of Furnace.	AMERICA. Eastern Pennsylvania.	Central Pennsylvania.	Pittsburg (large furnace).	Shenango (small furnace).	Shenango Valley.	Lake Front.	Birmingham, Ala., District.	Northern Alabama.	ENGLAND N. W. Coast.	Middlesbrough District.
Approximate weekly make ...	Tons 1000	Tons 1500	Tons 4000	Tons 1750	Tons 3500	Tons 1500	Tons 1200	Tons 900	Tons 850	Tons 620
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Keeper ...	8 2	7 8	10 11	10 5	10 5	11 5	7 3½	7 1	10 6	10 1½
First Helper ...	6 5	6 3	8 6	8 4	8 4	9 2	6 3	5 10	8 2	6 2
Second „ ...	6 5	5 10	8 1	8 4	8 2	9 2	5 11	5 2½	—	—
Slagger ...	5 5	5 10	7 5	8 4	8 4	9 2	5 0	5 2½	8 2	6 9
Caster ...	—		6 0		6 3	9 2	—		6 1	—
Scrapper ...			6 0		6 3	9 2	—	4 7	6 3	—
Water Boy ...					—			2 0	3 9	3 9
Stove Tender ...	7 1	6 0	8 11	8 4	8 9	9 2	7 3½	6 3	7 8	7 1
Filler Foreman ...	—		12 6		8 4				—	—
Fillers ...	—		7 6	8 4	6 3	8 2	5 0	4 7	8 2	6 7
Top Fillers ...	7 1	6 3	8 6	12 6		9 2	6 8	6 8	8 2	7 11½
Lime „ ...	6 5			7 11		—	—	4 7	3 7	6 5¾
Weighman ...	—	6 9	9 5		8 9	—	4 7	5 2½	5 4	5 3½
Hoist Engineer ...	8 4	5 10	9 5	—	8 9		—	—	7 6	6 5¼
Sweepers ...		—				—	4 7		3 9	4 1½
Stock Unloaders ...	5 2½	5 10		9 0	6 3	6 3	—	4 2	5 9	7 0¾
Pig-lifting ...	Direct Metal and Casting Machine.	Casting Machine.	Direct Metal and Casting Machine.	7d. ton. Chills	Direct Metal	7d. ton. Sand.	6 10 Sand.	7 7½ Sand	5 4/16 d. ton. Pig breaker	7 11½ Sand
Blast Engineers ...	8 4	9 5	11 7	10 6	10 5	12 6	9 5	8 4	7 11	7 11
Oiler ...	—	6 3	7 4		7 6	9 2	4 7	4 2	6 0	3 9
Cleaner ...	—		6 10			—	—	—	—	—
Boiler Tenders ...	6 3	6 3	10 6	8 4	8 4	13 6	6 2	6 3	6 8	7 5
„ Firemen ...		5 10	7 7		—	—	—	—	—	5 6¾
Yard Loco. Driver ...	—	8 4		—	12 6	—	—	8 4	7 9	7 4
Conductor ...	—	6 8			8 4	—	—	6 3	—	—
Fireman ...	—	5 10			9 2	—	—	5 2½	5 8	5 8½
Slag Loco. Driver ...	—	8 4	8 4	—	—	9 5	—	7 3½	6 4½	7 4
„ Fireman ...	—	5 10	7 5		—	—	—	4 9½	5 3	5 8½
„ Conductor ...	—	6 8			—	—	—	—	—	—
Labour ... (per hour)	6½	5½	6	7½	7½	7½	4½	4½	4¾	4¾

The above rates, unless otherwise stated, represent the wages paid per 12 hours shift (1 shift in America, 1½ shifts in England).

CHAPTER XII.

Future Markets for American Iron and Steel.

AT present, all the activity displayed in enlarging, rebuilding and in construction of new iron and steel plants has not provided sufficient capacity to fill the demand of a nation growing largely, not only in population, but still more in wealth and industrial development. It is said that the amount of iron and steel consumed per annum per caput of population is a true index of the civilisation of a nation. If this be correct, then America's people stand ahead of all others on the globe, because nowhere else is iron and steel used so lavishly and in so many forms as in the United States. Millions of miles of telegraph and telephone wires, other millions of miles of barbed wire fence, over 200,000 miles of railways with an equipment of over a million freight cars and about 40,000 locomotives, steel buildings up to 30 storeys in height, thousands of miles of pipe lines sending a steady flow of mineral oil from distant regions to the seaports, or distributing the waters of the mountain streams over the vast stretches of arid plains, and all other staple articles into which the metal is formed, have not only absorbed the whole of America's production of iron, which in the year 1900 amounted to 13,789,242 tons, but a deficiency in the supply had to be filled by importation of German steel.

But the greater the present activity, the more enormous the call for steel in all its various shapes, the greater is also the danger that when this demand falls off, even by a small percentage, this small percentage in the shape of hundreds of thousands of tons of material which must be disposed of, will be thrown on to the markets of the world, and, with the usual American energy, placed in competition with the product of other countries. At first, of course, the neutral and colonial markets will be canvassed, but if the over production should fill even these, an aggressive export business of American iron and steel products into Europe must be feared.

It is not likely that any large quantity of American iron will find its way abroad in the shape of pig-iron, except, of course, foundry iron, of which a considerable quantity is coming, and more will come, into European markets. But the bulk of American metal will appear in the shape of finished steel. Billets, rails and shapes, locomotives, cars, bridges, wire nails, tools, plates and bars are some of the articles which the excellent equipment and large productive capacity of the American shops and works will make it possible to sell at low prices.

When speaking of costs, it is, of course, impossible to quote the source of information, but the figures which I give below are, I am confident, *bonâ fide*, and were given me by men who are thoroughly familiar with this subject.

Foundry Iron is likely to be shipped partly from eastern furnaces, partly from the south. A large furnace in New Jersey

can now manufacture No. 1 foundry iron at a cost of 36s. 6d. The freight rate to New York is, for ordinary business, 2s., and somewhat less for export. From New York to Liverpool, freights for pig-iron vary from 6s. to 12s. per ton. No. 1 foundry iron might, therefore, at the present time be delivered in Liverpool at from 44s. 6d. to 50s. 6d. per ton, not allowing for profit.

At Birmingham, Ala., foundry iron to-day is costing about 37s. 6d. per ton. This iron is produced in old-fashioned furnaces with heavy coke consumption, expensive labour and small output. Mr. Don Bacon, the recently-elected chairman of the Tennessee Coal, Iron and Railroad Company, has been publicly quoted as saying that he expects to bring down the cost of foundry iron in this district to 25s. per ton. From Birmingham, the iron would be shipped to one of the following five ports:—

New Orleans, La....	417 miles.
Brunswick, Ga.	448 „
Savannah, Ga.	448 „
Mobile, Ala.	276 „
Pensacola, Fla.	255 „

The railway freight for export from Birmingham to either of these places is, to-day, 5s. 10d. per ton. The sea transport for iron carried as ballast in cotton ships to Manchester is 8s. per ton. Southern foundry iron can, therefore, to-day, be delivered in ship in Manchester at a cost of 51s. 4d. per ton; but if the prediction of the head of the leading southern iron company should be verified (and there is no question but what costs in the south will be rapidly reduced), southern foundry iron laid down in Manchester may before long cost as little as 38s. 10d. per ton.

How far panic prices of labour, machinery, fuel and freights will tend further to reduce these figures remains to be seen.

The north will not compete abroad with pig-iron. At present Bessemer iron in the Ohio Valleys, or at Wheeling, is said to cost 45s. 10d. per ton. The lowest average converting costs may be taken at 16s. 8d. Steel billets in the Wheeling district do, therefore, at present cost 62s. 6d. per ton. In times of low prices, iron has, however, been made for 34s. 4d., and conversion into steel has actually been accomplished for 15s. per ton. The lowest possible cost for billets in the Wheeling district may, therefore, be estimated at about 49s. 4d. per ton, or say 50s. The ordinary freight rate from Wheeling or Pittsburg to Baltimore is 6s. 3d. per ton, but has, for export business, been done at 4s. 8d. Ocean freight has varied from 6s. to 12s. Assuming the average freight at 10s. per ton, to which figure the Americans confidently expect to bring it down, when having their own ships, steel billets could at the present high prices be laid down in Liverpool at a cost of 78s. 9d., but may, if times go down, be expected to arrive at a cost of about 64s. 8d. per ton.

It must be borne in mind that the costs quoted above are based on market price of raw materials, but as most of the large steel producers control their own ore, fuel and flux, the cost to pro-

ducers cannot be ascertained, but must be less than the prices named above.

In an interview, Mr. Charles M. Schwab made the statement that his policy would be to keep the plants of the United States Steel Corporation going at their full output, which, at their present rate of production, represents about nine million tons of steel per year. "We will sell all we can at home," he said: "what we cannot sell at home we will find a market for abroad, and we will rather sell at a slight loss than curtail our production." The wisdom of this policy, from an American point of view, cannot be doubted. The men who wield the destiny of two-thirds of the most important industry in the largest industrial country in the world, have in their hands an incalculable power for good or evil. A sudden move on their part towards curtailing production would at once throw the iron business and all kindred industries into a panic. The United States Steel Corporation supports, in supplying the wants of their works, hundreds of other plants—engine and boiler manufacturers, makers of paints, oils and other lubricants, pipe fittings, tools, brass goods, lumber, brick, cement, stationery, chemicals, instruments and what not. As long as the works of the corporation keep going apace, taking their usual supplies, all these industries and their hundreds of thousands of employés will be kept in activity. A sudden retrenchment or partial stoppage on the part of the giant corporation would immediately throw them all into partial idleness and create widespread financial distrust and distress.

While unchecked and unlimited competition in the iron industry was the order of the day in America, such sudden stoppages did come periodically and with scant warning, causing great and unexpected fluctuations in prices and changes in economical conditions. It is to be hoped, and many believe, that the Steel Corporation will make the world its debtor by using its great influence in its own interests as in that of others, to prevent and minimise these sudden fluctuations.

From our point of view in England, on the other hand, this policy certainly carries with it great menace. The Steel Corporation controls a practically unlimited capital, and the best mines, the best coke, the best plants, the best lines of communication, the ablest managers, and the most perfect selling arrangements. When this great syndicate deliberately decides to sell a certain small percentage of their enormous output at cost, or even at a loss, in our own territory, such an action will be apt to demoralise our prices, and to send us through such a period of reorganisation, failures and destruction of capital as America experienced in the long-to-be-remembered years between 1893 and 1897. But as America, during these years, after learning the dearly bought lesson, pulled itself together and created the present successful organisation of its iron and steel business, so, I have no doubt, will Great Britain do.

There is no point in the world that need teach Middlesbrough a lesson in the cheap production of iron and steel. The Durham coke if properly made, is equally good, if not better than that of Connellsville. The collieries and coke ovens are nearer to the Tees than

is Connellsville to Pittsburg. The Cleveland hills yet contain a goodly store of iron ore, if also the grade is going down. To enrich the mixtures the Scandinavian mines, considerably nearer to Middlesbrough than are the Lake Superior fields to Pittsburg, supply an even richer and better raw material. In the opposite direction, Spanish hematites are available with easier transport than that of the Lake ores. Middlesbrough has also the advantage over Pittsburg of being located on the sea, and in the midst of the densely-populated European countries. If, therefore, the Middlesbrough ironmasters adapt—not copy—American methods, not only as regards furnace plants and steel works, but also, and of still more importance, as regards generous employment of money, consolidation of interests, control of raw materials, selection of managers and treatment and control of labour, they should never need fear competition from an industrial centre situated 3,500 miles away from the markets at their very door, and this opinion, I take it, will also hold good for South Wales, the Midland districts, and Scotland.

Nor does the world stand still while the iron industry is growing and developing. New markets, new employments, new needs arise and multiply, and therefore it is, in my opinion, certain that there will be room for us all in the future, as in the past, though the preponderating influence in the iron world, and the largest outputs of iron and steel, counting by nations, will, during this and the next generation, continue to be found on the western side of the Atlantic Ocean.

It is an axiom that no nation can remain or become a world power without the aid of an adequate iron industry. Great Britain cannot, and, I am sure, will not see its iron industry permanently lose ground. If, therefore, which I do not believe, it should come to pass that protected America to such an extent makes free trade Britain the market for such a surplus of iron and steel products as cannot elsewhere be disposed of, that the home industry of the latter country seriously and permanently suffers thereby, it must be remembered, that nothing but the will and dictum of the British people keeps the door open for such imports, and that it is practicable, if not to close the door, at least to place such a barrier across it as to give those inside a chance to live.

MILLOM, CUMBERLAND,
January 9th, 1902.

ON THE STEEL WORKS PLANT AND EQUIPMENT OF THE UNITED STATES.

BY ENOCH JAMES.

IN accordance with the arrangements made with the Executive of the British Iron Trade Association, I proceeded to the United States in the autumn of 1901 for the purpose of examining and reporting on the conditions and recent advances of the steel works of that country, in respect of processes, plant, and equipment. I deemed it my duty to see as many of the leading steel works as I could in the time at my disposal, and I believe the following observations will be found to have been based on a sufficiently wide range of visits and inquiries to be fairly typical of American practice of the best kind.

SECTION I.

The Bessemer Steel Process.

IN order to examine closely the manufacture of steel by the Bessemer process the following works were visited, viz. :—The Cambria Works, Johnstown ; Edgar-Thomson, Homestead, Duquesne, and Jones & Laughlins Works, Pittsburg ; Sparrows Point, Maryland ; Lorain, Newburg, and Youngstown, Ohio ; and Joliet and South Chicago Works, Illinois.

At each of these eleven works the acid process is carried on, and no basic Bessemer was being produced.

Since the visit of the Iron and Steel Institute to the States in 1890, four of the above works have been erected, viz., Sparrows Point, Duquesne, Lorain, and Youngstown, O.

For general arrangement and lay-out of the works in proper sequence for the respective operations these possess many advantages over the other works ; more room and better railway facilities to suit the improved methods of working being carefully provided. Apart from this there is not much to choose from, for at all the older establishments much progress has been made in modifying old plant and introducing the best practice under the circumstances. One of the first impressions created is the rapidity with which any new feature introduced at one works is adopted by all the others.

In a comprehensive report made upon the various works visited

by the Iron and Steel Institute in 1890, the metal mixer is stated to have been seen at Edgar-Thomson only; to-day it is found at all of the works visited, the large outputs obtained at the former having compelled other producers to ascertain the reason and adopt similar appliances.

As may perhaps be expected, the world's record for a converting shop with two vessels is now held by one of the new works mentioned viz., Duquesne; the best 24 hours' production (on the 21st February 1901) was 2,171 tons, which has since then been beaten at the same plant, the tonnage now amounting to 2,335 tons. In the month of May, 1901, an average of over 1,900 tons of ingots had been turned out every 24 hours.

Compared with English practice this a marvellous performance, and the methods that have enabled this to be done have been the subjects of very careful study.

How is it done? is a question that is often heard by those interested and are not too incredulous to accept the figures as facts.

Fortunately, information upon these matters is becoming more general, but what is most to be desired is that what is known may be put into practice.

Comparison of British and American Practice.

To summarise a reply to the above question, it may be stated that, compared with English practice, the American Bessemer shops are called upon to do less work in converting a ton of pig-iron into steel; their methods of doing it are unquestionably better, and the means provided for doing it are superior to those seen in this country.

In other words, the great difference between Bessemer practice as carried on in the two countries is found in the quality of the pig-iron converted, in the use of a metal mixer, and casting ingots on cars, stripping outside the converter house, better blowing power, and other mechanical appliances for regular working. The most important feature is the quality of the pig-iron supplied to the converters. The length of a blow depends mainly upon the amount of silicon in the pig-iron. At the Edgar-Thomson furnace F, the analysis shows that in 1890 the silicon was 1·60 per cent. As this furnace has given the largest makes it is natural to assume that the silicon was somewhat lower than was obtained from the other furnaces in operation at that time. In 1896 Mr. Franklin Hilton, in his notes upon the same works, gives the silicon as 1·25 per cent. Now, however, 1·00 per cent. is not often found, and ·80 per cent. is quite sufficient for the Bessemer shop. This reduction in the content of silicon is due to the fast driving of the blast furnaces, and also to the low percentage of silica found in the iron ores. As this comes within the scope of the Report of my colleague upon blast furnace practice it will not be dealt with here, further than to say that faster driving at the furnaces has resulted in a pig-iron that is more favourable to the converting department and requires much less blowing to purify it.

Many blows were seen started and finished in eight minutes, and as two blows were often proceeding at the same time, the number of blows was increased. At South Chicago, on Wednesday, August 7th,

1901, with the weather exceedingly warm and the people dying in the cities owing to the heat, 15 blows were obtained in one hour.

This was done with great ease, for no men could stand much exertion that day, and yet the work proceeded without any fuss or difficulty. The iron was at the exact pitch, there was a plentiful supply at hand, there was little or nothing to do to the tuyeres, three converters were fully occupied, and there was no waiting for casting ladles or the clearance of ingots, but each section did its share of the work with smoothness and regularity, like automatic machinery. This was the quickest working witnessed at any of the works, and it clearly shows what the possibilities are when the iron is the lowest in silicon that will pass with the quickest working.

Again, at the Edgar-Thomson Works on Tuesday night, July 16th, 1901, 110 blows were made, after a shift of 97 blows on Tuesday, followed by 96 blows on Wednesday. For large outputs these works and South Chicago have for a number of years run a very close race.

The amount of slag produced at each blow is much less than with us, this depending, of course, upon the percentage of silicon in the iron.

Notes on Methods of Working.

In dealing with pig-iron low in silicon the method of operating had to be adapted to this quality. Rapid working became essential. The amount of heat derived from the oxidation of the silicon was limited, and had to be utilised to the best possible advantage. Converter bottoms had to be altered and the best form discovered to suit these conditions. These vary somewhat at the different works, but all show a larger number of tuyeres or blast area on the bottom than is usual in England.

At one of the most modern, the bottoms have 16 tuyeres with 11 holes ½ in. diameter. Several of the older plants have 19 tuyeres with 7, 10, 12, and some with more holes, each ½ in. diameter. These tuyeres are inserted if the iron is changeable and requires more or less blast.

The average number of blows is uniformly high, 30 and 32 is not uncommon, and difficulties from this source are seldom met with.

The blast pressure in general use is 25 lbs., but the tendency at some of the best conducted shops appears to be to reduce the blast pressure, and the valve was lifting at 19 lbs. This appeared to me to be due to the high percentage of iron found in the slag. More attention seemed to be directed to this point at these works than is generally the custom. Some analyses of converter slag gave over 25 per cent. of iron. One sample contained a good deal of steel shot, but several others gave as much as 20 per cent. iron. At the first glance this appeared much worse than the English practice, and might be caused by rapid working; after making several enquiries at sundry places, I found it was not uncommon, and it arises from the fact that the amount of slag made per ton of steel is less than in England. The total loss of iron may therefore be no higher, even although the percentage of iron is higher in the American slag.

Next in importance to low silicon in the pig-iron, in its influence upon the output, is the supply available. When blowing rapidly, the iron must be plentiful, and promptly charged into the converters in order to avoid delays, which not only are so much time lost, but cause the vessels to cool down, and make it difficult to proceed at all.

Cupolas.—In order to maintain a regular and sufficient amount of molten iron to the converters, melting cupolas are in general use, and do not differ much from those in use in England. The most notable feature is the large number of tuyeres through which they are supplied with blast; 30, 40, 60, and, in some cases, even more tuyeres of about 3 in. diameter were seen. Blast is obtained from fans, and is therefore comparatively low in pressure; 6 to 8 ozs. of water was frequently seen. Some of the cupolas have melted large quantities—200 to 250 tons in 12 hours—when required.

In a few cases successful attempts have been made to charge the cupolas mechanically, and Wellman-Seaver charging machines are beginning to find favour for this purpose.

As all of the works enumerated are equipped with blast furnaces, the re-melting of pig-iron is avoided as much as possible. And herein lies one of the saving elements of the Bessemer process. At the Edgar-Thomson Works, with eight blast furnaces in operation, the melting cupolas are not used at all. At South Chicago, again, where the blast furnace power is so great, very little cupola iron is required. The sunday iron is taken away to the open-hearth plants and is used for foundry and other purposes.

Considerable attention is given to this point. At the largest installations the blast furnace power is being increased, as the limit of the production of steel has been reached, until the supply of molten iron is improved.

With the greatly increased production at the blast furnaces obtained by fresh additions to the blowing power and quicker driving, the quality of the iron has turned out more suitable for the Bessemer shops without re-melting; the amount which they can convert has been greatly increased, and the supply has been overtaken.

The cupolas are mostly placed near to the converting shop. In some cases they have been most conveniently arranged in the mixer house, and the iron from cupolas is passed through the mixer, along with that obtained direct from the blast furnaces. In no case is any attempt made at using hot blast for cupola work, and in this respect some of our old English plants have a decided advantage in lower coke consumption, larger output, and less loss of silicon in re-melting.

The regular supply of molten iron to the converters was attended with much trouble and difficulty at the blast furnaces when direct working was first introduced. It is so to-day at those works in England that have not yet adopted the metal mixer. One ladle is taken to the blast furnace, about five tons, more or less, is tapped out, and the blast furnace keeper is asked to stop the tap hole of the furnace against 10 or 20 tons of iron that may be ready for casting at the time. To enable this to be done, the tap hole has to be of a particular form and well under control. This hole

requires renewing once, if not oftener, each week, and causes a stoppage of the furnace from three to six hours, or even more, every time.

The ladle, with its five tons or so, is afterwards taken to the melting cupolas, and is filled to the required weight before reaching the converting department.

Metal Mixers.—This mode of working is possible only with the small quantities dealt with in England, and to meet the altered conditions in America Captain William R. Jones introduced the metal mixer at the Edgar-Thomson Works. The blast furnaces are tapped with regularity, as if casting into a pig bed, and all the iron they contain at the time is taken into ladles; these are removed by locomotive power, and their contents are tipped into a large vessel, which is constructed in such a way that it can pour the molten metal into ladles standing on a lower level. These ladles are taken to the converters, and are kept going independently of any temporary stoppage at the blast furnaces.

When first introduced, these mixers were made to hold about 80 tons each, two such vessels being used. At that time a cast of 40 tons from a blast furnace was seldom obtained, and this, being divided into two mixers, made it possible to mix the product of several furnaces at the same time and hold a sufficient quantity in reserve to supply the converters as often as iron was required. The blast furnace was cast every four hours, and all the iron was conveyed into the mixer, the tap hole being repaired in a few minutes in a way that was good enough for this mode of casting, so that no stoppage for a day's repairs during the week was necessary. The other great advantage derived from the metal mixer is that of equalising the product of two or more furnaces.

When eight furnaces are at work, the quality of the pig-iron produced varies considerably, and the percentage of silicon from each furnace differs according to the conditions and circumstances. It was soon found that the effect of mixing the product of as many furnaces as possible was very beneficial in averaging the silicon, and also the sulphur; and a more uniform grade of iron was supplied to the converters.

To-day, mixers of 200, 250, and even 300 tons capacity are found in use, and large sizes have become general. One of these is represented by the accompanying photograph of the operations at the Duquesne Bessemer department (Fig. 1).

The molten iron is conveyed in ladles from the blast furnaces; they are lifted by means of a 50-ton four-motor electric overhead travelling crane. The span is about 72 ft., and the lift is 40 ft. The mixer is mounted on rollers and is tilted by a hydraulic ram and cylinder. The ladles to be filled are placed upon a weighing machine, and, after receiving their charge of iron, are moved to the vessels by means of wire-rope haulage. This is fed by natural gas supplied through a pipe in the end of the mixer.

The pouring into the mixer is done by means of separate winding gear attached to the crane, and is controlled by the crane man without any aid.

Direct Pouring from Ladles. This mode of charging into the mixer brings to recollection the fact that in no case, so far as can be recalled, was molten iron seen poured direct from a ladle into the Bessemer converter, as is so common in English works. No

[illegible]—200-Ton Hot-Metal Receiving Mixer Tank and 50-Ton [illegible] Overhead Travelling 4-Motor Crane at Duquesne. Span 71 ft. 6 in., Lift 30 ft.

one seemed to have any special reason for the practice. Troughs and narrow channels are used from the ladles to the vessels, and the cooling effect upon the molten iron must be increased in relation to the length of the time taken in pouring. Scrap also requires handling and troughs take fixing and repairing.

In observing closely the operation of charging I noted that it was done frequently under two minutes between the turning down and the turning up of the converters.

This does not leave much room for improvement, as one might suppose; but if ladles were emptied direct into converters, as they are in England, or as the Americans do into the mixer, there is reason to expect that the time would be further reduced, and the iron would be subjected to less cooling action by being poured over a cold surface in a small stream.

Casting Ingots on Cars.—Another important improvement in methods has been the casting of ingots upon cars, and stripping them outside of the converter house.

The latter had been introduced at the Edgar-Thomson Works in 1890, and no doubt led up to the further advance of casting the ingot upon cars that would convey them direct to the cogging mill when stripped of their moulds.

This plan has greatly reduced the heat inside the shop, and has contributed largely to the comfort of the men. The work has also been reduced, and mechanical appliances have replaced hand labour to a considerable extent.

The work is performed in a better way also, as the ingots are stripped more quickly, and are delivered to the soaking pits long before the steel has solidified in the centre of the ingots.

This has resulted in much gain to the heating furnaces and to the working generally. The coal consumption has been much reduced, the steel has had better treatment, and the clearance from the casting and converting shop has seldom interfered with the progress of the work.

The arrangements for doing this differ slightly at the various works, but the leading features are identical. The ladle containing the steel is conveyed by electric overhead travelling cranes in some cases, and by fixed radial roof-supported cranes in others, to a casting platform. The ingot moulds are placed upon strongly built cars, with removable bottoms; they are brought into the converting shop by a locomotive, are filled with steel, and are then moved along by a hydraulic pusher, with a stroke equal to the distance from centre to centre of the cars. As soon as the cast is teemed the cars are taken out to the open air, and the ingots are allowed to cool before being stripped of their moulds.

The ingots are mostly of fair weights; 19 by 17 by 72 is a standard size of mould for rail-making purposes, the length, of course, being governed by the weight of rail required. Where 4 by 4 soft steel billets are made, the ingot moulds are filled up to a contracted top, and weigh about two tons. At the largest works, eight ingots are made at each cast, but where the vessels are small the number of ingots per cast is less. With this method of casting and with an ingot weighing about two tons, the difficulties attending pit casting in England are almost entirely done away with.

Stripping Ingots.—After casting, the ingots are removed to the stripping house, which is mostly found placed as near to the rolling mill as possible. Two tracks of narrow-gauge railway running parallel

to one another are bridged over by a wrought-iron structure carrying the hydraulic cylinder and ram used for lifting the ingot and mould. There is a double motion—the hooks which hold the mould ascending when the ram descends into the mould, and pressing the ingot out until it reaches the car. The moulds are transferred laterally on to an empty car, standing opposite to the full car upon the other railway track.

A large number of cars and ingot moulds are in constant use at the Edgar-Thomson Works; upwards of 150 cars with 300 moulds are in daily use.

Where the number of moulds is limited, and watering becomes necessary, the life of the mould is shortened and the labour and expense are increased.

An ingenious stripper worked by electricity has been designed by the Wellman-Seaver Company, and finds favour where hydraulic pressure is not convenient.

Blowing Power.—The means for doing work are in proportion to the demands made, and ample provision is made for keeping the machinery in good repair whilst driving hard. The blowing engines seen were excellent machines, well adapted for their work, and there were enough of them. In many places a spare engine was in readiness to start at once, should any accident cause a stoppage to one of the others. At the Edgar-Thomson Works there are five blowing engines—three Mackintosh-Hemphill engines of 450-h.p. each, one E. P. Allis Company engine of 750-h.p., and one Southwark 750-h.p. single engine for blowing four converters.

At South Chicago Works there are two pairs of vertical engines, and two single horizontal engines for blowing three converters.

At some of the other works visited, blowing power was undergoing extension. More attention appeared to be given to compounding, and the horizontal type is getting into favour. In one instance only was any complaint made of want of blowing power, and this was at a plant where the blast furnace output was very favourable, and the mill capacity was equal to all the steel it could get, making the converting shop the weakest link in the chain, and consequently causing it to come in for most attention.

Double Pouring.—Double pouring is not adopted generally, and it was at the South Chicago Works only that this was seen done. The ladle receiving the cast from the converter is lifted by means of a crane and the contents poured into a casting ladle, supported by another roof-fastened crane. All the operations and movements of cranes are regulated at will from blowers' pulpits. Considering the great advantage derived from this method of working upon the regularity of the steel made, by the better diffusion of the carbon and manganese, it is rather surprising that this practice has not been more widely taken up, particularly by those engaged in the manufacture of tin bars and material for sheet-making.

Length of Blows.—As a consequence of the low percentage of silicon found in the pig-iron dealt with, the blows are seldom continued so long as in England, yet the resulting steel is so low in silicon that grey

pig-iron rich in carbon and silicon is added to the spiegel at cupolas, in order to give the requisite amount of silicon in the steel demanded by the specifications worked under, as well as to improve the steel for rolling purposes. This practice was seen at several of the works engaged in making steel for rails and other high-carbon material.

It is this constant attention to weak points and the readiness with which appliances are provided to meet new methods, that has enabled large outputs to be produced. The latter is by far the most important feature in its influence upon the development of the manufacture, and is one worthy of admiration.

At one of the best known and most successful Bessemer shops it was stated that the whole plant had been reconstructed four times during the last 25 years, down to the very foundations, and this, too, under the supervision of the same engineer—one who was in daily touch with the plant, who had been compelled to deal with troubles and failures of many details of vital parts, and who knew the requirements better than it would be possible for any other man to do. This was really the most distinguishing characteristic of American works, observed throughout the whole of the iron and steel making districts. No amount of rivalry amongst operators would produce improved results without the power of applying the fruits of their knowledge and their experience of the special conditions under which their work is carried on. But with an immense command of money, and a thorough knowledge of every detail of the plant used in this process of manufacture, the relative proportion between the various sections has been arrived at with much greater success than is found in England.

Take for example the number of converters employed. At two works only, those of Cambria and Edgar-Thomson Works, were four converters used. Three were in operation at the same time, and one was undergoing repairs when necessary. The blowing power provided is sufficient to deal with three casts at the same time, and two casts were constantly going together. At one works in England having five converters in use, the blowing power is not sufficient to blow more than one cast at a time. The proportions between converters and blowing engines are clearly in error here. This is not a solitary case, for at some other English works the blowing power is not capable of blowing two casts at once.

The same remarks apply to boiler power. No instance came under notice where stops for steam are now heard of. The number of boilers is arranged so as to be capable of supplying the blowing engines with a constant supply of steam if necessary. All this is very simple, and very well known to those engaged in the business, but the practical application is not so easy.

That the rivalry which exists amongst the various managers in the United States is productive of real progress, no one will doubt for a moment. This spirit is spread to the workmen and is encouraged as a matter of course. There is a marked difference in the extent of acquaintanceship with one another's works and methods compared with what is the case here. The publication of records, and the desire to maintain or beat them, creates an enthusiasm which it is refreshing to see when directed to the accomplishment of a useful object. These,

however, are not the only means made use of for securing good service. When a piece of good work is done by any member of the staff, when any improvement worthy of adoption is suggested, or when any achievement outside the ordinary run is attained, it is not unusual for the successful worker to receive recognition in a special manner. If he be a manager it may be in the form of a three months' trip to Europe, with the needful ways and means. If a foreman has broken all previous records at a new plant, a gold watch and chain may be his reward. Fresh records may yet be expected, although some people are inclined to think that the Bessemer process is doomed, and will be eventually displaced by the open-hearth. This probably will not happen soon, if ever, whilst ores suitable for the process can be procured at the same price as high-phosphorus ores, for the amount of money laid out in improving the Bessemer shops, and the great increase in the tonnage produced, with decrease in cost as a matter of course, will make it more difficult for any other process to beat it upon its merits. With the advance made in blast furnaces, and increased outputs, the pig-iron made will again become more favourable for turning out still larger quantities. When the Carrie blast furnaces, now in course of reconstruction, are got to work, the Duquesne Bessemer department will be further heard of in this direction. And it will be a disappointment to many if the South Chicago Works, with two additional blast furnaces now in course of construction there, will not have improved opportunities for demonstrating their capacity for bigger things, and that very shortly. There is no finality in metallurgical or mechanical matters, and American steel makers certainly show no inclination to rest; whether they are as thankful as they ought to be is not quite so clear. They have been favoured by nature with superior materials, they have assiduously and energetically applied themselves to treat these materials in a better way, and they have displayed undoubted confidence in their resources and in themselves by investing large sums of money in improving machinery and replacing obsolete tools. They richly deserve all the success which they have attained. They have had capable leaders who have secured the assistance of experienced superintendents, and they have wisely adopted effective means at all costs for doing the work cheaply and well. For all this they are now reaping their reward.

SECTION II.

The Open-hearth Process.

THIS process was seen in operation at the following works, viz., Homestead, Duquesne, Jones & Laughlins (Pittsburg), Cambria (Johnstown), Pencoyd, Bethlehem, Sharon, Latrobe (Pa.), Newburg (O.), and South Chicago.

Great strides have been made during the last ten years both in the producing capacity of the older plants and in the number of new works erected to carry on this process.

This may be accounted for by the suitability of the steel produced for making plates, sectional bars, and other articles demanding mild and soft material. This partly accounts also for the rapid progress made by the basic process, for the difficulty of obtaining steel sufficiently free from phosphorus by the acid process to meet the tests demanded in materials for shipbuilding and structural purposes could scarcely be overcome in any other way. Nearly all the furnaces seen were basic-lined, excepting the few engaged in producing forgings, armour plates, and tyres.

The development at Pittsburg alone represents an enormous increase in producing capacity, and the latest additions at Duquesne and Homestead are brilliant examples of modern melting shops, which, for boldness of conception, efficiency of design, and excellence of erection, have seldom, if ever, been known in the history of open-hearth steel making.

At Homestead there are three shops in all, consisting of 8, 16, and 24 furnaces, respectively. No. 1 shop has two rows of four furnaces. The tapping holes are nearly upon the floor level, holes for casting ladles being made in the floor.

Each furnace has two roof-supported cranes, one of 60 tons for dealing with the ladle, and one of 5 tons for dealing with the slag. The ladles, after receiving the cast of steel, are lifted out of the pit and placed upon a bogie, which is moved by a locomotive to the casting pit at the end of the building. Two circular casting pits are served by casting cranes and ingot cranes, similar to the usual method in old Bessemer practice. Each block of furnaces is supplied with a Wellman charging machine, and in this respect is similar to all open-hearth plants seen, with the exception of two 20-ton furnaces making steel for locomotive tyres. The chief feature of all the open-hearth furnaces in the Pittsburg district is the use of natural gas. And a very important feature it is. As a matter of course there are no gas producers, making the demand for ground usual with the open-hearth process much less than is the case in England.

This is not altogether an unimportant matter, even in America, for the general impression that prevails with regard to having plenty of room does not always hold good. At many of the older establishments the land is as scarce and the conditions are as difficult as any in this country. With a river on one side, a mountain on the other, and a railway track of some large public company on another, some of the works are as cramped for space as any in this country.

Then the traffic is much reduced. No coal wagons are required, nor space for storage of empties. The labour of dealing with ashes in every stage is entirely dispensed with, and the influence upon the working of the furnaces is decidedly favourable.

The quality of the gas and the regularity of the supply are far and away better than is possible with any arrangement of gas producers yet in operation. This gives the steel melter one leading condition that is constant, and enables heat to be obtained when required—that is to say, intense heat, and any amount of heat, at the command of the operator when circumstances arise calling for it.

At No. 1 shop the charging platform is upon the ground level, with the regenerators for air only under the platform.

One furnace of 30 tons capacity has a movable roof, which is raised by a crane and moved by hydraulic power. Through this opening large lumps of skull, rolls, ingot moulds unbroken, and any big lumps are charged. With the large quantities of such material seen lying about various works, it is surprising how others have not copied this form of furnace. The repairs to the roof must be heavy, but this expense is trifling compared with the gain in converting material of such sizes into practical use, and keeping the works clear of accumulations that are as unsightly as they are costly.

The other seven furnaces at Homestead are of 40 tons capacity, and are constructed in the ordinary manner.

At No. 2 shop there are now 16 furnaces, arranged in a double row, with holes in the floor for ladles. After casting, the ladles are conveyed by two powerful electric overhead travelling cranes, capable of lifting 150 tons each. Under these cranes ingots for armour plates are cast.

At No. 3 shop there are 24 furnaces, all of 50 tons capacity, arranged in two rows, with ample room for working in every way. This shop, with that at Duquesne, where 12 furnaces are arranged in one row, are the latest examples of such plants under the Carnegie Company.

The output at the latter for the month of May, 1901, the best hitherto attained in some respects, was 1,419 tons every 24 hours, or upwards of 700 tons per furnace per week.

Whilst the comparative difference is not so great as in the Bessemer practice as carried on in England and in the United States, yet it is at least equal to twice as much as the best English practice.

In Bessemer practice, it may be stated briefly that two converters in America turn out as much steel in one day of 24 hours as two similar converters turn out in a full week in England. With the same number of men, the tonnage per man would be represented by six in America to one in England.

Fig. 2.—Low Type Wellman Open-hearth Furnace Charging Machine

FIG. 3.—CHARGING CARS AND BOXES.

In open-hearth practice the number of men would be less upon the whole, and the tonnage per man would be about 2½ tons to one in England.

This great increase in output, compared with that turned out in England, has been brought about within a short space of time, and is by no means exceptional. The conditions necessary for development have been carefully studied, and the appliances necessary for the application of new ideas have been supplied.

The Wellman Charging Machine.

One of the most important of these was the mechanical means of charging invented by Mr. S. T. Wellman. Manual labour was thus greatly reduced, the time taken to charge was shortened materially, and the number of heats turned out was increased as a consequence. This machine has been widely adopted, and has contributed largely to the success of the open-hearth process.

The Wellman charging machine is electrically driven, and does the work easily and well. One machine attends to four or five furnaces. A few of these great labour-saving machines have been introduced in England, and have been found quite as suitable and successful as in America. Owing to the height of this machine some of the works had not head room enough, and a new type of machine has been introduced, which is much lower and equally effective. The latter are in use at both Homestead and Duquesne. All the materials are dealt with in the stock yard, and placed with one handling from railway trucks into the charging boxes; three of these are placed on a car, and the cars are removed and taken into the melting shop by locomotive power. The various types of Wellman charging machines are shown in Figs. 2, 3, 4, 5 and 6.

Details of Plant, etc.

The stock yard at Homestead is equipped with two 5-ton electrical overhead travelling cranes, with a span of 55 ft. 6 in., and a lift of 25 ft., built by the Morgan Engineering Company, of Alliance. Two lines of railway, and one line for the charging cars are laid under the cranes, and the exact mixture of pig and scrap and other materials required for each charge, is filled from railway trucks into boxes and conveyed to the furnaces in the order required. If the cars are full and the railway trucks are full and wanted, storage is found for good quantities upon the floor that is available whilst trucks are being replaced.

Over the fronts of each row of furnaces, cranes of 40 tons capacity are erected, supplied with two winding barrels for dealing with molten iron, similar to that seen at the Duquesne mixer.

The molten iron is passed through a mixer which holds 250 tons, but the supply from the blast furnaces is far from sufficient to enable many of the open-hearth furnaces to be worked with direct metal. This is the direction in which future developments may be expected, as most of the new plants are making better provisions for dealing with molten iron.

The casting arrangements are also modified and improved. The most general custom is the use of overhead electrical cranes for dealing with the ladle. The casting process differs according to the con[illegible]: if ingots are large, they are placed in a pit and grouped [illegible] from below.

Fig. 49.—Picture of Crane Type Heating Furnace Charging Machine, at the Works of the Carnegie Steel Company, Pittsburg, Pa.

FIG. 6.—HEAD TYPE WELLMAN OPEN-HEARTH FURNACE CHARGING MACHINE.

The crane has two lifting barrels, one for 75 tons and one for 25 tons, for dealing with moulds. These cranes are strongly built, and are quick in all their movements. The Morgan Engineering Company have also an electro-hydraulic crane for this purpose. The ladle is lifted by hydraulic power, whilst the travelling motions are obtained from electric power. This type is not widely adopted, though possessing some advantages over the ordinary form of construction.

Casting on cars is frequently done where small ingots are required and stripping is done outside the shop, as is the general practice in Bessemer shops.

The arrangements for charging and for dealing with the steel made are most complete, and well proportioned to the capacity of the plant, and the consequence is that 14, 15 and 16 heats per week are got from these large furnaces with less physical exertion on the part of the workmen engaged than would be necessary in England for half that number of casts.

One very important difference is found in the quality of the pig iron used, and in the proportion of steel scrap charged, when making large outputs. In most instances the pig-iron contained under 1 per cent. of silicon, with phosphorus from ·3 to ·7. In no case was 1 per cent. of phosphorus seen, whilst several instances were found with about one-tenth only. No attempts are made to produce specially high phosphorus in the pig-iron, with the view of getting slags rich in phosphoric acid, and the slags, therefore, are of no use for fertilising purposes. Whilst this may be a loss in one way, it is not a disadvantage from the producer's point of view. There is much less work to be done to purify the pig-iron, and it takes less time, requires less flux, and makes less slag, whilst the quality of the steel required is much more easily obtained than when working with a pig-iron containing from 3·0 to 3·5 per cent. of phosphorus. This, with the large percentage of heavy steel scrap, was one of the chief points of difference in open-hearth practice as carried on in the United States and in England.

The Rolling Furnace.

The form of furnace employed has been given much attention, and one of the most noteworthy departures has been the rolling melting furnace invented by Mr. S. T. Wellman.

This Wellman rolling type of furnace has been in operation in the United States since 1889, but it is only recently that their number has increased rapidly. In view of the attention given to the Talbot process it may be interesting to quote the inventor's description of the Wellman rolling furnace:—

"The furnace consists of a very strongly framed steel shell or casing of an approximately rectangular section, inside which the lining of silica bricks is built up. On the underside of the structure are fixed two curved cast-steel rockers, which are supported on strong steel standards with horizontal upper surfaces; when tilting to pour off, the furnace moves forward on these rockers. The rolling move-

FIG. 7.—EXTERIOR VIEW OF THE AMERICAN STEEL AND WIRE COMPANY'S OPEN-HEARTH PLANT AT NEWBURG WORKS, CLEVELAND, OHIO.

[illegible] Interior View of the Open Hearth Steel Plant of the American Steel and Wire Company's Newburgh Works, Cleveland, O., Showing Four 50-ton Wellman Rolling Open Hearth Furnaces.

ment is accomplished by two hydraulic cylinders mounted on trunnions at their lower ends and having the upper ends of their piston rods attached to their pouring side. To tilt the furnace, water is admitted to the top end of the cylinder. In case of accidental failure of the hydraulic system the furnace returns by its own weight to the normal or melting position."

A special feature of these furnaces is the water-cooled front and doors, greatly reducing the danger of the men becoming overheated while employed in front of the furnaces.

The advantages of the rolling furnace are stated to be as follows :—

Between 40 and 50 of this type of furnace are now in operation in America, whilst 10 are about to be built in England.

As with every other new departure, considerable differences of opinion are held regarding this form of furnace, and some of the earliest operators having had some experience of them are not adopting them, whilst making further extensions. The Cambria Company have had two rolling furnaces at work for several years, but do not find it advisable to go in for them now, for in their new shop they have erected six furnaces of 50 tons capacity, of the fixed type with raised platform, after the English style. At South Chicago, also, some of the earliest attempts were made with rolling furnaces, and the experience there is not very favourable. It may be that many of the defects of the initiatory plants have since been improved, and late comers derive the benefit of having weak parts strengthened.

One of the best instances of a plant worked upon this plan was seen at the American Steel and Wire Company's Works, at Newburg, Ohio. Here four furnaces, each of 50 tons capacity, were at work. The tilting is done by two hydraulic cylinders, fixed on the casting side of the furnace. An overhead electric crane conveys the ladle from the furnaces to the teeming platform, where the ingot moulds are brought on cars—carrying two each. When filled they are taken outside the melting shop to an ingot-stripper, where the moulds are taken off, and the ingots are delivered hot into the mill. All steel made was for wire making. The slag was poured into a bogie and removed by railway trucks. They had upwards of 10,000 tons of ingots during the month of May, and had not experienced any difficulty with the furnaces. Nor had the roofs given any trouble since the plant had been in operation. Labour cost was stated to be low, and the work was done with ease, and the surroundings kept clean. These furnaces are supplied with producer gas and work cold pig-iron, and the product is all soft steel. (Fig. 8.)

The largest number of rolling furnaces is found at the works of the Tennessee Company, Ala., where ten of 50 tons capacity each are in operation. Another example of their use is at the steel casting plant of the Shickle, Harrison & Howard Co. at St. Louis (see Fig. 9).

Notwithstanding the first cost of construction, which must be considerable, the hydraulic power must be found, and this would tend to increase the difference in first cost as compared with the fixed type of furnace. In spite of this fact, when 14 or 15 new plants have adopted the rolling furnace, there is every reason for concluding there must be important advantages secured in the opinions of those who invest their money to that extent.

FIG. 9.—STEEL CASTING PLANT OF [illegible] & HOWARD IRON COMPANY, EAST ST. LOUIS, ILL.—VIEW OF CHARGING FLOOR, SHOWING [illegible] WELLMAN TILTING FURNACES AND CHARGING MACHINE.

The Talbot Process.

The largest size I have seen in use is at the Pencoyd Works, Phila., where the Talbot process was inaugurated, and is now carried on with a furnace of 75 tons capacity. Others of much larger capacity are in course of construction at the works of Jones & Laughlins, Pittsburg, for working the Talbot process. If this process proves successful in operation, it will have been rendered possible by the rolling furnace, and this may be one great inducement for those now erecting new plants to adopt the rolling form, as they can thereby work either system.

The Talbot process was seen in operation at Pencoyd Works on two separate occasions. One rolling furnace is there placed at the end of a row of 10 fixed furnaces, each of 30 tons capacity. Molten iron is supplied from a pair of cupolas placed in a direct line and close to the melting furnaces. After casting 25 to 30 tons of steel out of the furnace, the molten iron is conveyed by a ladle from the iron cupolas by an overhead electric travelling crane, with double lifting gear. One chain is fastened to the top of the ladle, and the other to the bottom. The trough is placed in one of the furnace doors and the molten iron is poured from the ladle into the furnace. The crane driver controls the pouring with great precision, and charging is done quickly and well.

A weighing machine is placed upon the floor for weighing the ladle and the charge, and afterwards re-weighing the ladle so as to get the weight of molten iron charged with accuracy.

After the iron is charged into the furnace, the action is very rapid, and the ebullition is great. Gas is then put on, the temperature is raised, and the charge is worked in the usual manner. The slag is poured off the surface, and the heat comes into contact with the metal in the furnace.

The chief claim made on behalf of this process is the improved yield of ingots as compared with that of any other mode of working. It is stated that 107 tons of ingots and steel scrap have been produced for every 100 tons of molten iron charged for a period of six months, the increased yield, of course, being derived from the oxides introduced in the form of ore, mill scale, and cinder, as well as due to the protection the metal receives whilst under treatment.

The yield question, to be tested properly, requires great care in conducting the operations, as well as keeping correct records of the figures. At Pencoyd the process is not tried under the best possible conditions. There are no blast furnaces to supply molten iron. The cupolas supply iron to the other fixed furnaces, and, although the molten iron is weighed separately, the loss in cupolas and wages is common, and apportionment is necessary, as they cannot be kept distinct.

The same remark applies to the gas supply, for the producers are not separate from the other furnaces and the coal consumption cannot be arrived at for any particular furnace. The working is, however, attended with great ease, and despatch is obtained without any physical labour on the part of the workmen.

Among the advantages claimed for the process the following may be noted:—

1. The delivery of hot ingots to the blooming mill furnace with more regularity.
2. A saving of 25 per cent. to 30 per cent. in first cost of plant.
3. Only one-third of the space is required for a given capacity.
4. Twenty per cent. less fuel is required per ton of ingots produced.
5. The labour per ton is less than one-half.
6. The yield is greater than has ever been reached by any other process.

Whether all of these claims can be realised it is perhaps rather early to predict, but from anything seen or heard so far, there are no data forthcoming to support them.

Considering the circumstances that prevail at Pencoyd, and the limited amount of ground at command, it was not confirmatory of these claims to find extensive alterations and improvements being carried on with furnaces of the old form. One of the most obvious lessons I gathered from visiting so many works was the promptness with which any good idea was taken up and adopted. If the Talbot process effected anything like the savings claimed for it, the Pencoyd Company would doubtless have found them out ere this, and two or more of the old furnaces would most likely have made way for another rolling furnace. The gain in space alone would be of great advantage at these works, for further extension is scarcely possible excepting by changes of this character.

When the Jones & Laughlins furnace, of 200 tons capacity, is erected, and is supplied with molten iron direct from the blast furnaces, this process will be conducted under better conditions, and further information will be obtained as to the success of the method of working. Considerable doubt exists as to the superiority of this process with regard to the quality of the metal produced, and statements were often heard that better results in low phosphorus are obtained from the older method of working.

The Monell Process.

Another new process was seen at Homestead, as introduced by Mr. Monell. A few furnaces at No. 1 and a few at No. 2 shop were worked upon this method.

As is generally the case when introducing a new system into practice, with the surroundings laid out for some other system of working, many makeshifts had here to be resorted to and inconveniences put up with that would disappear if a plant were laid out with a view to operating upon this plan. Charging molten iron has been successfully done by applying a motor to the ladle. This motor was carried on the locomotive bringing in the ladle. Current is derived from one of the Wellman charging machines on the platform. The oxides are charged first and the molten iron afterwards. The slag is tapped through a tap hole in the front and run into a hole made in the ground, into which some iron hooks are placed. The lumps are lifted out when cold and taken away in railway wagons.

Very rapid working is obtained when everything is in suitable condition; and excellent results were reported. The supply of molten iron at Homestead is derived from two blast furnaces only,* and although the quantities these produce is very large, viz., 600 tons per day of 24 hours each, it is not sufficient to keep the Bessemer plant and many open-hearth furnaces supplied. In addition to this, there is greater difficulty in securing basic pig-iron of the exact composition than in getting grey iron for Bessemer purposes. And with one furnace only producing at a rapid rate there is not much chance of mixing or securing that absolute uniformity which this method of working appears to require. White iron, containing under 1 per cent. of silicon with low sulphur, is always difficult to produce, and complaints are soon heard if silicon goes too high or too low. The result of low silicon is soon observed in cold heats, and the danger of excessive skulls is much increased by working molten iron direct. The responsibility rests chiefly with the blast furnaces, and it will be a surprise to many operators if the limit in producing capacity of these blast furnaces has not been exceeded, if regularity of product is desired, and open-hearth direct metal working becomes more general. With two furnaces making 300 tons each, the chances are better than two to one against one furnace making 600 tons per day, for the liability to extreme variations is much reduced by more moderate driving.

The Monell process was not seen adopted at any other works, nor was it so extensively employed at Homestead as to lead one to suppose that there was much benefit to be derived from working it†. This may be due to want of means for supplying molten iron of the exact quality desired and not to any defect in the system itself.

It was clear that, given certain conditions of working, excellent results are obtained; and it remains to provide the requisite conditions always, and the problem will be solved. This, no doubt, will be done with time, once it is clearly established that it pays to do so, for the difficulties in the early days of Bessemer direct working were not overcome without considerable modifications of the previous customs and practices of blast furnacemen.

The Sharon Steel Company's Plant.

Two newly-erected plants were seen at the Cambria Works, at Johnstown, and at the Sharon Steel Company's Works, at Sharon, Pa.

The buildings in which the furnaces are placed are of steel frame construction, covered with corrugated steel sheets. They are most substantially built, and afford better head room and working room generally than any other plants I have seen.

Both plants are similar in many respects, and differ from most of the other American plants in being built above ground, with an elevated charging platform, as is the common practice in England.

* Those are the furnaces known as the Carrie, which are now increased to four.

† At a later date, the Monell process had been discontinued at Homestead, according to information supplied to me in October. [EDITOR.]

At Cambria six furnaces, of 50 tons capacity each, were at work. They were equipped with Wellman's charger, a 75-ton casting crane,

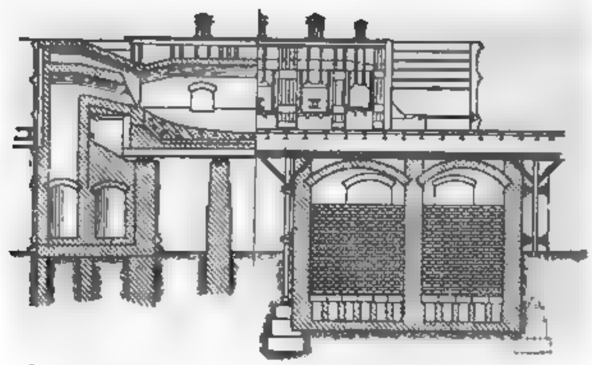

FIG. 10.—SECTION OF OPEN-HEARTH FURNACE AT THE SHARON STEEL COMPANY'S WORKS, PA.

and all the other requirements of the very best type that could be obtained. They were supplied with gas from a row of gas

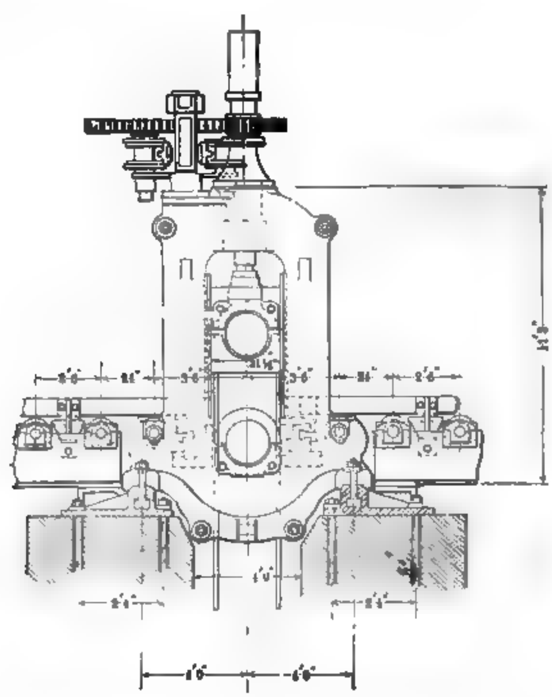

FIG. 11.—SIDE ELEVATION LLOYD-BOOTH 38-IN. BLOOMING MILL AT SHARON STEEL COMPANY'S WORKS, PA.

producers placed alongside the melting shop. The ingots were poured at a casting platform, and stripped outside the shop on their way to the cogging mill.

At Sharon, there were eight furnaces built, also of 50 tons capacity. These are the most modern furnaces, and represent the latest practice in the United States. The following particulars of

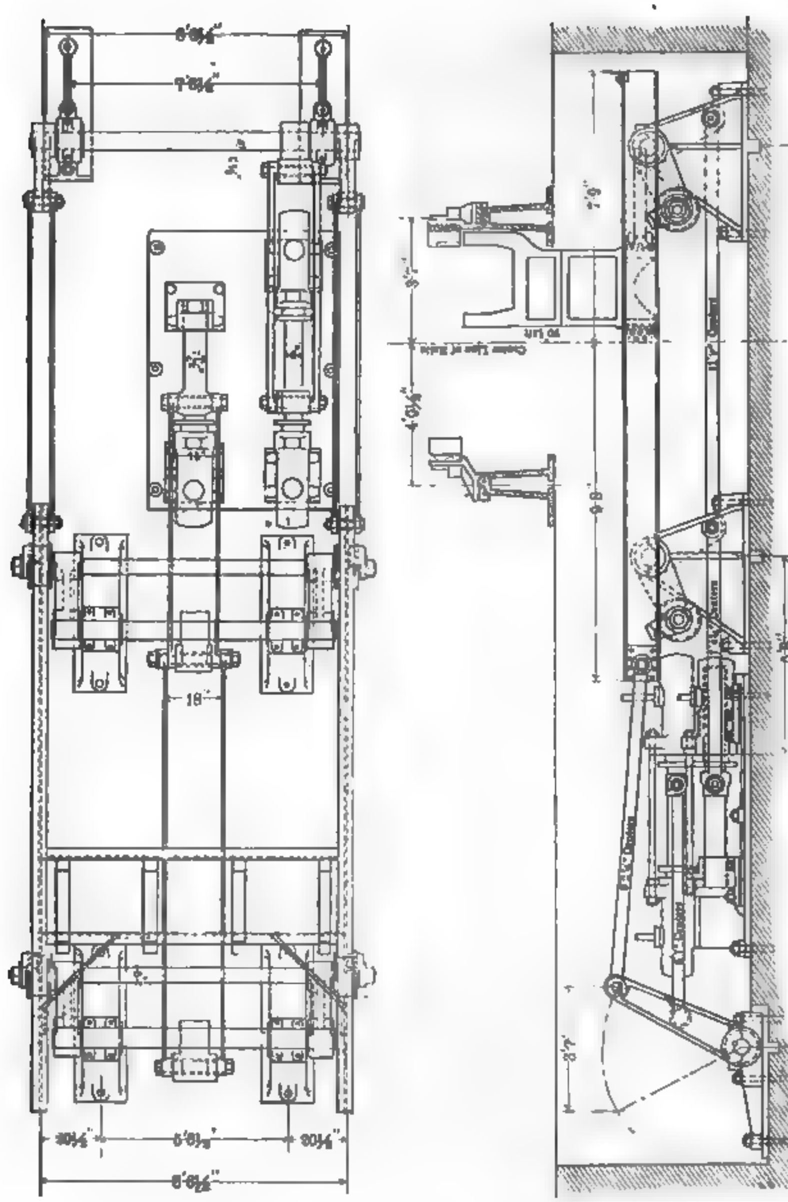

FIG. 12.—ELEVATION AND PLAN OF MANIPULATOR AT SHARON WORKS.

them are taken from a descriptive article that appeared in the *Iron Age* for July 4th, 1901:—

"The company was formed on October 3rd, 1899. In July,

1901, they had one blast furnace, eight open-hearth melting furnaces and a cogging mill at work, and already extensions are decided upon.

"The basic open-hearth steel plant consists of eight 50-ton open-hearth furnaces (Fig. 10) and is contained in a main building of steel frame construction 603 ft. long and 123 ft. wide (Fig. 14). There is an elevated charging platform and the furnaces are provided with regenerative

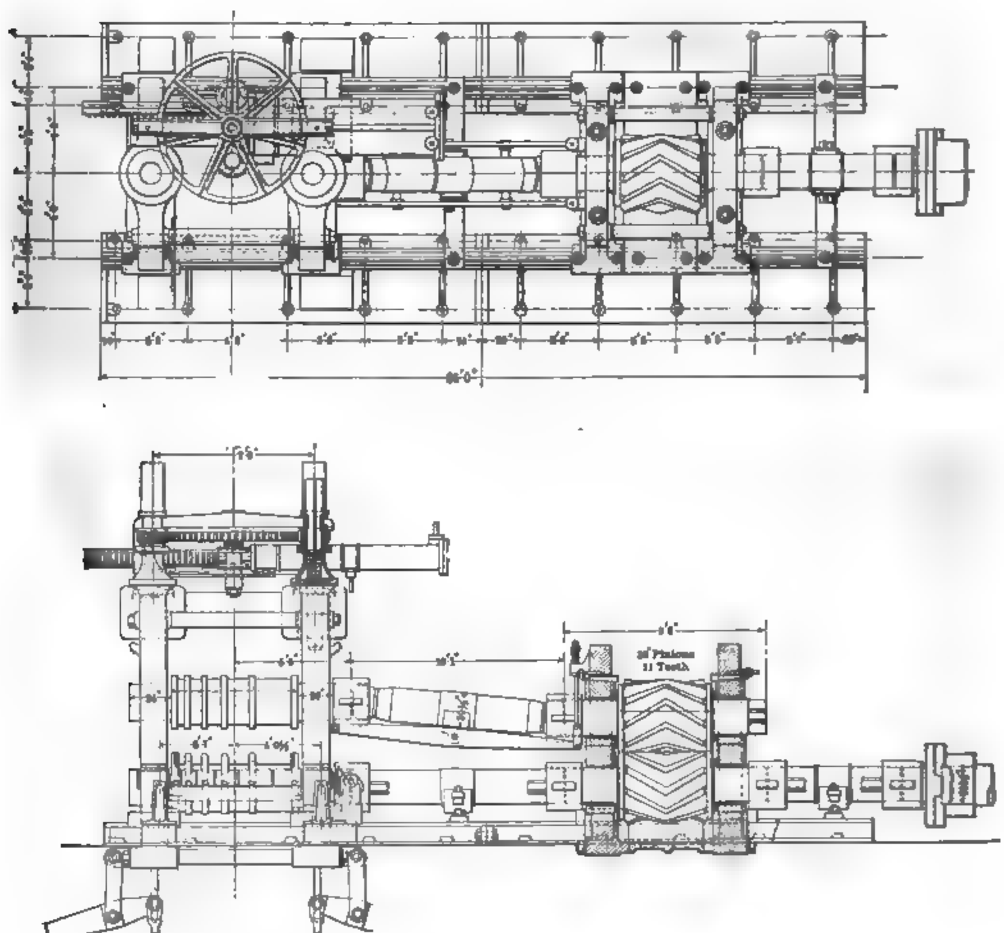

Fig. 13. Plan and Elevation of 38-in. Lloyd-Booth Blooming Mill at Sharon.

chambers for air and gas, having reversing valves operated by means of a hydraulic cylinder. The charging side of the furnaces is equipped with a 4-ton Morgan crane, while the pouring side is equipped with a 75-ton crane of the same design. The furnaces are charged with a Wellman-Seaver charging machine and are also equipped with water-cooled doors and frames. A unique feature in the erection of the open-hearth furnaces is that they are built above ground,

resting on iron columns, making them easier of access when repairs are being made, which insures a more even temperature and also does away with casting pits. There are two pouring platforms equipped with 50-ton ladles, the output of each furnace being 15 to 18 ingots per heat. Each furnace has a battery of four water seal gas producers, each 13 ft. high and 10 ft. in diameter, built by the Sharon Steel Company from their own designs. The gas producer house (Fig. 15) is provided with coal storage bins, from which coal is taken up by an electric travelling conveyor, installed by Heyl & Patterson, of Pittsburg, to bins above the gas producers. From these bins the coal is taken to the gas producers by an automatic

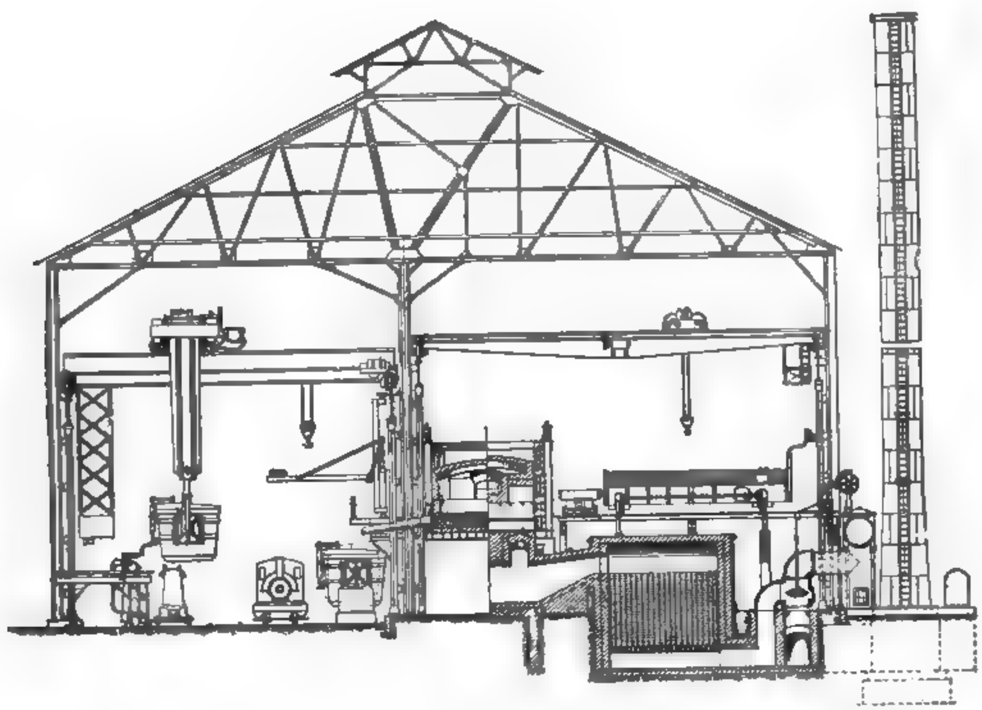

FIG. 14.—CROSS SECTION THROUGH OPEN-HEARTH BUILDING AT THE SHARON STEEL COMPANY'S WORKS, PA.

feeding device. Another innovation made by the Sharon Company in the building of their works is that the stock house for the open-hearth furnaces is covered, affording protection from the weather to the materials in the stock house and also to the men employed there. The stock house is a steel and brick building 1,000 ft. long by 60 ft. wide, and in it is stored the pig-iron and scrap used in the open hearths. The stock house is equipped with two heavy shears used for cutting up billets and rails to the proper lengths for loading into the charging boxes. The stock house is also

equipped with four railroad tracks, one being elevated. Two of these tracks are used for materials coming in to be unloaded, and two for materials loaded and going out to the open hearths. At the end of the stock house is a mixer house, for grinding limestone and other refractories.

"The ingots are taken from the open-hearth building to the stripper building, where they are stripped by an Aiken ingot extractor.

"The whole plant of the Sharon Steel Company, from the blast furnace to the finishing mills, is thoroughly modern and equipped with the very best machinery that money could buy. The projectors

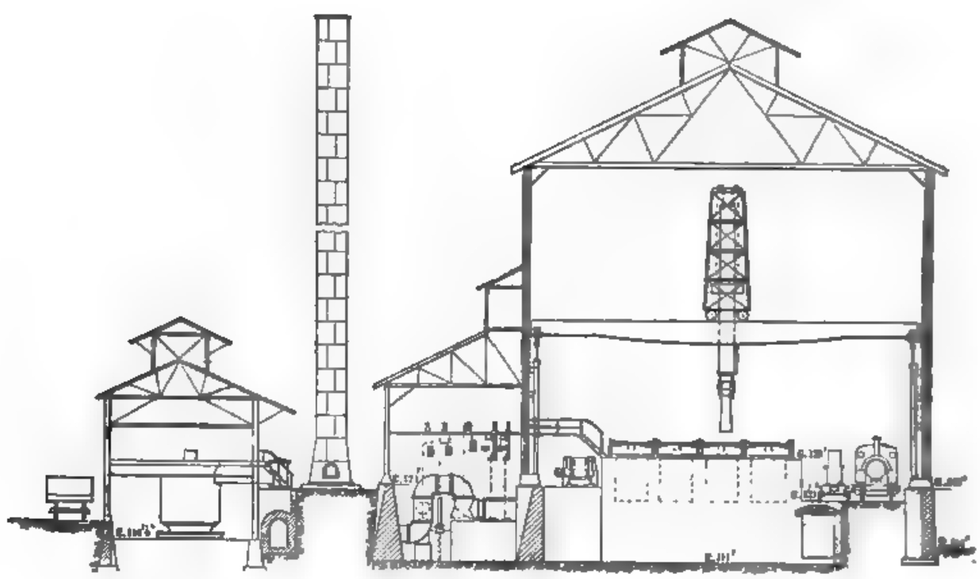

FIG. 15.—CROSS SECTION OF PRODUCER AND RE-HEATING BUILDINGS AT THE SHARON STEEL COMPANY'S WORKS, PA.

of the plant had constantly in view the building of the mills that could be most economically operated and at the same time turn out a maximum of output.

"There is probably not a concern in the country to-day better equipped for manufacturing at a low cost than the Sharon Steel Company."

With this view most people with whom the writer came in contact agreed. The general arrangement of the plant has been well considered, the various departments being well placed, and conveniences for handling heavy traffic being admirable. The machinery is of the best known types, made by most experienced makers, and there has been no stinting of mechanical appliances for every conceivable purpose throughout the whole plant. Details of the rolling mill machinery are shown in Figs. 11, 12 and 13. Reference will be made to them later.

Conditions of Labour.

Great attention has been given to the improvement of the conditions of labour and the introduction of mechanical means for reducing hand labour in every direction. At the open-hearth plants the charging machine has been of immense advantage, and has reduced the labour of charging to a very low point. Its adoption has been very general, in spite of many difficulties of situation and surroundings at some of the works. No open-hearth plant of any size was seen without its charging machine, involving in some cases a separate generating station for supplying the electric power. The time occupied in charging has been reduced very considerably, and the loss of heat and injury to brickwork of the furnaces by changes of temperature has also been reduced, thus contributing towards quicker working all round. Furnace doors are mostly lifted mechanically, and everything in connection with charging hot metal has been arranged with the view of reducing labour and saving time. Casting on cars and stripping outside the melting shop has made this section comparatively easy, and the working space much cooler and more comfortable for the workmen.

With such conditions the amount of work turned out has gone up step by step until 15 and 16 casts per week are now frequently obtained. For this purpose the workmen have done their best to rival one another, and holding back for fear of earning too much money is not heard of. It is an acknowledged principle that when any new method of working is introduced which shall reduce the labour of the men and increase the output, there shall be a revision of wages. No difficulties are put in the way of a new machine, for the men have seen sufficient to learn that they have been the greatest gainers by the introduction of all labour-saving machines. At one establishment visited there are three distinct types of melting furnaces in operation, working under different conditions, of varying sizes of furnaces; and the men in attendance at each type of furnace are paid different rates per ton. The men are much easier to control, and are kept under better control in consequence of being easier to replace. Manual labour has been so reduced that driving can be kept up without any effort, and the amount of money laid out is so great that any want of attention on the part of the attendant cannot be tolerated. If English workmen applied themselves to get the best possible results out of the machinery and plant in their hands, they would have less to fear from the competition of the United States or any other country. And if employers were able to secure fair reductions when introducing new methods the extent of renewals and the scrapping of obsolete machinery would increase rapidly.

Rolling Mills.

Rails.

lowing works, viz., Edgar- town, Youngstown Ohio.

mills is specialisation, and specially for rolling rails. detail, they have all the

to this country are the The large quantities been watched with much methods have been studied as could afford. During the 1890 they attracted much the most attractive subjects

at South Chicago was 660 per month was 6,766 and records were 1,417 tons per day, nth. Now at each of these and upwards of 1,200 tons

its exceedingly hot weather, mason, and only a few shifts

given plant has been doubled brought about by constant ols, so as to secure regular

chinery itself have not under-

train, and the roughing and arate engines, running at high object sought after, but speed also considered. This practice rail rolling is carried on in the

been made in supplying the

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mills with hot steel. The rolling plant is equal to all the ingots that could be got, but as the improvements in the Bessemer shop caused it to become more productive, the necessity arose for taking care of the steel. In order to do this, vertical soaking pits have been introduced, instead of the horizontal heating furnaces, and

FIG. 16.—ELECTRIC PNEUMATIC (FIVE ELECTRIC AND ONE PNEUMATIC MOTORS) E.O.T. CRANES, 52 FT. SPAN, LIFT OF GRIPPING TONGS 13½ FT. BUILT BY MORGAN ENGINEERING COMPANY FOR LORAIN.

the methods of charging and drawing ingots have undergone a complete change.

Modern Cranes.

By casting ingots on cars, and stripping them at a separate shop, they are delivered into the rolling mills very quickly, and quite hot —much more quickly than the steel solidifies. The ingots are still

in a perpendicular position, and quick handling has demanded something better than the old tongs, with a special attendant to open and close it. This difficulty has been overcome by the Morgan Engineering

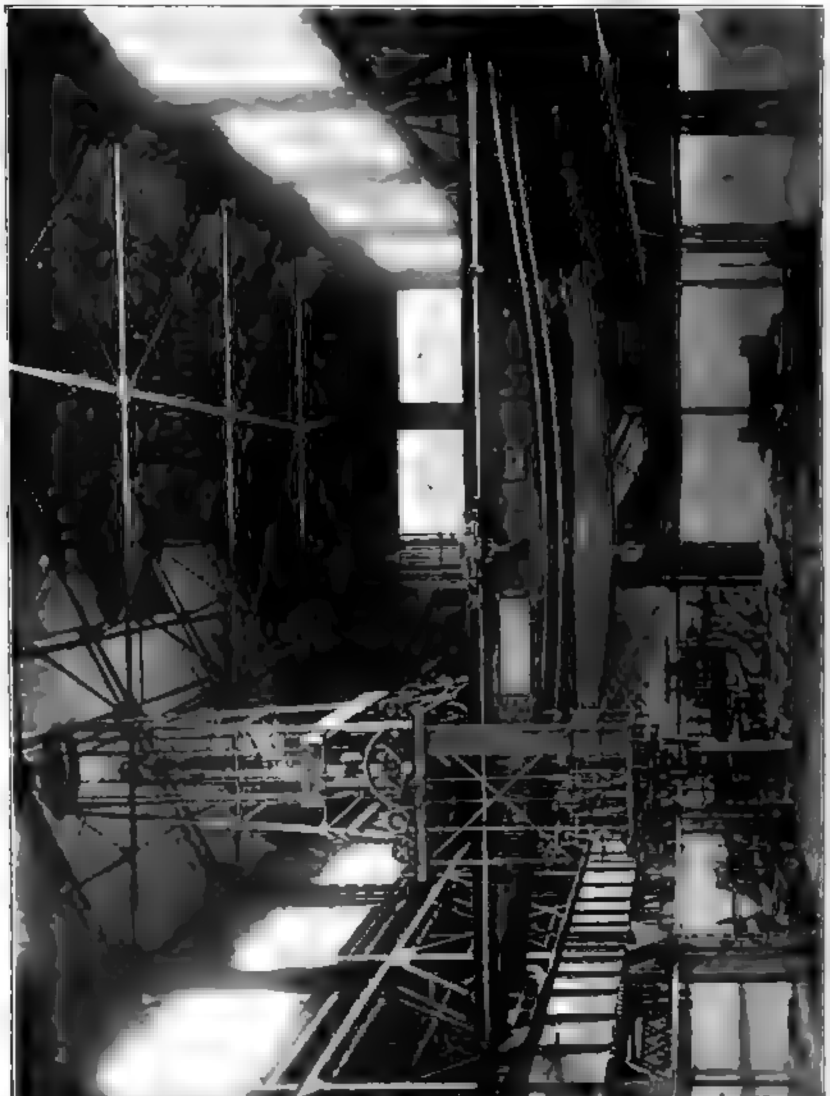

FIG. 17.—5-TON VERTICAL CHARGING CRANE, AT CARNEGIE STEEL COMPANY'S WORKS; LIFT 15 FT.

Company. Their 5-ton charging crane is one of the most successful tools for handling ingots known in American practice.

The first crane of this type was introduced at the Edgar-Thomson Works, but it was soon adopted at many other works, including the National Steel Company's Works, Ohio, where it was seen in operation. The lift is 15 ft. and its speed is remarkable, all movements being

controlled by the operator, who is placed under the crane and right above the work to be done. The opening and closing of the jaw is well under control, and the form of the jaw is such that it can be conveniently dropped over the ingots.

The one great trouble found with this crane has been the uncomfortable position of the crane-driver, owing to the heat, and in warm

FIG. 18. 50-TON CAPACITY ELECTRO-HYDRAULIC LADLE CRANE, 62-FT. SPAN, 16½-FT. LIFT, AT STEELTON WORKS.

weather his powers of endurance have been the measure of the possible output. Relays of fresh hands have had to be found in order to relieve each other at intervals.

Two cranes were found in use, one for charging and one for drawing, making each operation distinct and capable of being carried on at the same time, with one to spare. The number of soaking pits has been augmented as wanted, until ample provision is made for receiving an hour's output of ingots. This large number of pits does not mean

FIG. 19.—HOMESTEAD STEEL WORKS, SHOWING TWO 5-TON L.O.J. CRANES, 55 FT. 7 IN. SPAN, 25 FT. LIFT (TROLLEY AND CAGE COVERED FOR OUTDOOR SERVICE).

FIG. 20. SHIPPING YARD AT HOMESTEAD WORKS, SHOWING FOUR E. O. T. CRANES—THREE OF 80 FT. SPAN; ONE OF 95 FT. SPAN, WITH 20-FT. LIFT.

an increase in the consumption of coal or gas, for the ingots are delivered so hot into the pits that the main point is to get them a suitable resting place until the centre of the ingot has become solid; and the heat given out being confined by the brickwork of the pits,

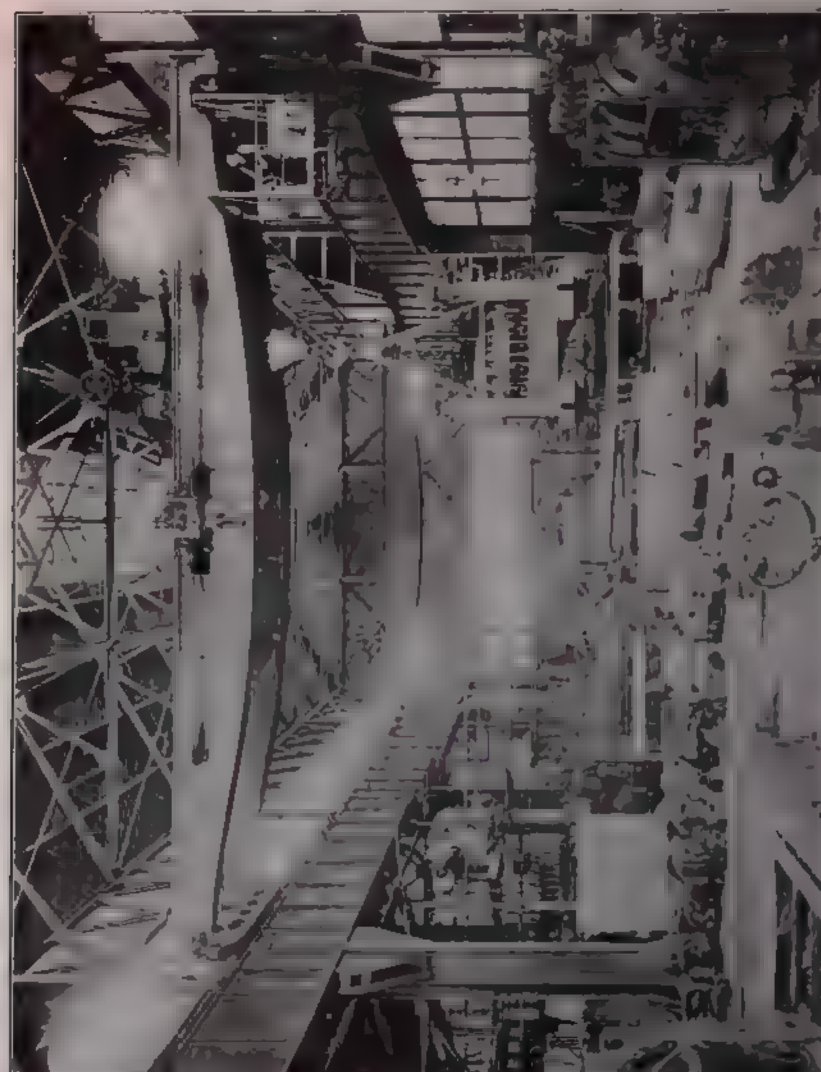

FIG. 21. INTERIOR VIEW STEEL GIRDER MILL AND STRUCTURAL DEPARTMENT AT LORAIN, SHOWING ONE 15-TON AND ONE 40-TON E.O.T. CRANE, 48-FT. SPAN AND 25-FT. LIFT.

a very small amount of gas is sufficient to maintain the necessary temperature.

Some Features of Rolling Mills.

It is to this modern practice of keeping the rolling machinery in constant work that the great increase in output is attributable ... the adjustment of the various operations in order to s

other has demanded an increase in heating capacity and quick-speed tools for charging and drawing the ingots out of the vertical heating pits, and transferring them to the table of the cogging mill.

With a good supply of steel delivered to the cogging mill as quickly as that department can deal with it, there is a very good chance of testing the capacity of the rolling mill machinery. At Edgar-Thomson the cogging is worked by a single cylinder engine, 44 by 66 in., of 1,200-h.p. The rolls are 40 in. in diameter, and three-high, with rising and falling tables on both sides, and equipped with a manipulator worked by hydraulic pressure on the front side. The ingots are reduced from 19 by 17 to a bloom of 8½ in. square, in nine passes. This operation occupies about 50 seconds. The bloom is cut in two, and all blooms are re-heated.

One novel feature of these works has been the manner of dealing with the bloom ends. They are dropped into cars under the shears, and those of each cast are weighed separately. Any excess of weight is at once noticed, and the teemer, who is responsible for the ingots, is informed and subjected to necessary discipline.

The blooms, when cut, are placed by live rollers upon a table which is moved electrically, and brought in front of the re-heating furnaces, of which there are five, with nine charging doors in each. These are charged on one side and withdrawn on the opposite side, and placed upon a similar carriage to be then passed on to the first roughing train.

This train is driven by a single cylinder engine, 26 by 60, with an excellent governor. The rolls are 37 in. diameter, and three-high, with tables and manipulator as in the cogging mill. There are five passes in this pair of rolls.

The second roughing train is driven by an engine 54 by 60, and the rolls are 27 in. in diameter, and have five passes, with two rails in the rolls together.

Before passing to the third and finishing pair of rolls, the rails are pushed to one side and allowed to cool down to a certain temperature previous to being passed through the last finishing groove. This mill is 26 in. in diameter, and is driven by an engine 38 by 48, of 500-h.p. The process described is called the Morrison & Kennedy cold-rolling process.

Sometimes eight or ten rails were seen standing together upon the benches cooling, while at other times there would not be so many, the number depending upon the temperature at which they came out. The fracture is closer, and the wearing properties of the rails are increased.

The rails are passed on to the hot saws, of which there are four, driven by one engine—in three lengths of rails. There are, therefore, only two crop ends and one bloom end, thus bringing the amount of waste down to a very low point.

On their way to the hot banks the rails are passed through a small pair of rolls for cambering, the amount of curve being regulated at will, to suit the section and temperature at the finishing point.

There are four hot banks, which are carefully arranged for the purpose of allowing the rails to lie straight. This is a matter of great

FIG. 22. INTERIOR OF RAIL MILL, [illegible] STEEL COMPANY, LIMITED, CHICAGO, ILL., SHOWING 10-TON SQUARE SHAFT DRIVEN O.T. CRANE, OF [illegible] SPAN, [illegible] BUILT BY MORGAN ENGINEERING COMPANY, ALLIANCE, OHIO, U.S.A.

importance and is done with considerable success, the amount of work saved to the rail straighteners being astonishing. The rails were taken by roller gear to one of the straightening presses, of which there are eight, with 32 drilling machines.

The finishing department is well arranged with the view of avoiding unnecessary handling, the rails being delivered to each press for straightening by means of switches upon the live roller gearing. After straightening, the rails are passed on to the chippers, who, in turn, pass them on to the drilling machines. From the drillers they are moved to the loading benches, where they are inspected and loaded on railway cars by hand. The elevation of the banks is very favourable for transferring and loading, as railway cars are so arranged as to stand upon a low level.

Great saving is due to the care taken in dealing with hot rails, and with their condition before going to the straightening presses. Many rails go through with no side pressure at all, and with but few strokes upon the head.

The inspection of rails, as carried on in this country, is out of the question, and the standard of finish is certainly not so high as is demanded here, but it is considered good enough for all practical purposes and the products are allowed to go through.

Makers are to a large extent their own inspectors, and they generally take care to pass no rails that they cannot stand by at any future call, so that, whether the buyer's inspector be there or not, loading is constantly going on at the rail bank.

Passing single rails by the buyer's inspector is not attempted, and, indeed, could not be done without a large number of inspectors. Moreover, any delay at the finishing department would run through all the producing departments very quickly, with the large quantities turned out.

The works are run as a whole, and delays at any section are therefore much sooner felt and are of increased importance.

If any delay should arise at the mills the Bessemer shop has to stop also, for cold steel is not acceptable, nor could it be dealt with under existing conditions without dislocating all the subsequent stages of the manufacture.

It is in the rolling mill practice that the mechanical engineering has been seen to the best advantage, and the appliances introduced have effected the best results in doing away with manual labour.

A tongs or hook is not seen near any of the rail mills visited, and the whole operation is conducted from a platform, where levers connected with the various live rollers and lifting tables are collected together. One man is in constant attendance, and his duties are so heavy that two men are "spelling" one another at short intervals.

The arrangements differ slightly at some of the other works, where the finishing is still further sub-divided and the rolling is carried on in four sets of rolls, with separate engines. This was seen at South Chicago and Youngstown, and five, six and seven pieces were being rolled at one time. At some of these places the roughing rolls had extra grooves for turning out 4 in. by 4 in.

Fig. 22. Interior of Rail Mill, [illegible] Steel Company, Limited, Chicago, Ill., showing [illegible] Square Shaft Driven O.T. Crane, of [illegible]. Built by Morgan Engineering Company, Alliance, Ohio, U.S.A.

together, the rolls being adjusted and fitted with all the necessary guides, so that on changing, the four holding down bolts would be unscrewed and the coupling box pushed back, the rolls taken out, and a new pair put in, without any needless loss of time. Two cranes of 40 tons and 15 tons power, respectively, having a span of 48 ft., and a lift of 25 ft., are placed above the mill engines and storage department. These cranes, which are driven electrically, are made by the Morgan Engineering Company. The finishing mills consist of two sets driven by two pairs of Galloway engines 48 in. by 50 in. and 45 in. by 48 in., the first driving two sets of rolls, two-high and 28 in. diameter, and one set of finishing rolls, also 28 in. diameter, being driven by the latter.

The finishing department is upon an extensive scale, ample room for hot beds, and means for transferring from one place to another being well considered. The machinery for loading as well as straightening, grinding, drilling and dressing before loading, is the best of its kind, and is laid out in a building of large size, which is substantially erected, affording room and comfort to the men engaged to carry on the work, regardless of weather conditions.

Extensive use is made of electricity, and pneumatic hoists for loading rails into cars are found most useful, as well as quick in operation. They are fixed upon runners, and one man lifts and loads into cars with great ease.

At Pencoyd the rolling of large beams is done with great success. The cogging mill is driven by a pair of reversing engines 40 in. by 60 in., geared one to two with the usual live rollers at the back and front of the rolls, which are 7 ft. long from collar to collar, and 36 in. diameter.

As an instance of how smartly work is done in the repairing of mill machinery, these engines may be noted. They had been driven hard for upwards of ten years, and the cylinders had worn out of truth. It was decided to reduce the diameter of the cylinders, as the engines were too much above any work called for. This was done by preparing two liners with new pistons and piston rods of increased diameter, having a hole through them. New cylinder covers were alike got ready with tail carriers running upon wheels. No tail carriers had been used before. New brasses were prepared, and all the valve gear joints were closed where necessary, and every working part was thoroughly examined and put into good order. All this was done in one week's stoppage of the mill. The preparation of all parts was done as far as possible beforehand, so that when the mill was laid off very little remained beyond taking out the worn-out parts and replacing the new. During the first visit I paid to these works, the engines had only been running a few days, and beyond an extra man engaged in oiling, the work was done as if the engines had been at work for months, while they were equal, if not better adapted to the purposes required than when first introduced.

The ingots used were 24 by 26, 20 by 24, and some for light working were smaller. Upwards of 500 tons of blooms were turned out in 24 hours. For large beams, the bloom is well shaped in the cogging, and is re-heated before rolling into a finished size.

Beams 24 in. by 7½ in., weighing 100 lbs. per foot, are rolled in good lengths, and the bars are sent out to the bank in full lengths, and sheared, when cold, to the required lengths. Deliveries of small quantities from stock is a matter of no difficulty with conditions of this description.

The finishing mills have three sets of rolls, placed side by side. The first is two-high with reversing 28-in. rolls. The other two sets are three-high, with 23-in. rolls, with traversing and lifting tables, worked electrically. The arrangement of these tables and bogies for transferring from re-heating furnaces, displayed as much mechanical skill as was observed at any such mills, with more electrical driving than is found at any of the others, with the exception, perhaps, of the new plant recently introduced at Jones & Laughlins, at Pittsburg. Here the circumstances required special treatment, and the automatic switching in of tables and starting of live rollers when the bloom was in proper position were exceedingly well done, and will avoid the necessity of any attention on the part of the attendant.

Pencoyd and Homestead.

The Pencoyd rolls for the finishing sets are fixed in the standards ready for changing complete, and are dealt with by an overhead electric crane of 40 tons power. Three sets are changed in a little less than an hour, whilst two sets are often changed in half that time. Considerable alterations in this mill were being carried on in introducing new soaking pits, and changing the delivery of blooms to the other side of the mill, making a decided improvement in the lay-out of the mill.

The finishing department was well provided with shearing machines, straightening presses, and other machines. Overhead travelling cranes, built by the Brown Hoisting Company, did the loading into cars.

At Homestead, the largest quantities are being turned out of every variety of shapes, in mills adapted for different sizes. The largest sizes are rolled off direct from the ingot, measuring 25 by 30. These are heated in 15 soaking pits served by an overhead electric traveller for charging and drawing ingots and delivering them to live roller gear. This conveys them to the cogging rolls, of 40 in. diameter, driven by a pair of Southwark engines 40 by 60. Here the ingot is formed into the shape of the beam. The blooms are passed on to the roughing train, placed tandem to the cogging mill. The finishing mill has three sets of rolls, of 35 in. diameter, driven by an engine 54 by 72 in., and is served by rising tables. When the bloom is too heavy to roll in one length, it is cut into two. The first part is rolled off, and the second part is retained in a covered furnace fed by gas, to keep it hot until the first part has been completed. It is rather peculiar to see shapes rolled off direct in this manner, and at the same time to find the Edgar-Thomson Works re-heating all blooms for rail making. The steel for rolling into beams and shapes is all open-hearth basic, and it is delivered to the mill at a good heat, and is well and quickly worked whilst hot. The output of this mill is upwards of 200 tons in 12 hours, and the whole number of men seen engaged in the actual rolling was one roller, four table men, and one sawyer, with two other assistants.

Beams are cut to length cold by means of a plain disc of steel run at a great speed, which goes through the cold beam just as quickly as when it is hot.

The finishing department is quite a factory, and is equipped with some very fine electrically-driven tools. Loading and stocking are done by means of overhead electric cranes, a group of seven 10-ton cranes, made by the Brown Hoisting Company, of Cleveland, being seen, covering acres of storage ground, with railroad tracks (Figs. 19 and 20). Here quantities of all sections are stored, and can be obtained at short notice without any additional cost, which is a most important element in this class of business; this enables the mill to roll considerable quantities whilst the rolls are in, and thus to avoid the loss of time and of output attending frequent changes of rolls for small quantities. This kind of work would not be tolerated, nor could the amount of steel dealt with be treated, if conducted as some mills are run in England.

The conditions as to convenience for handling materials are greatly hampered at Homestead, and the amount of capital outlay greatly increased in providing facilities to overcome this disadvantage. The amount of machinery and crane tracks is something enormous, and their construction and application has been the subject of careful and intelligent study. Cranes running on curved tracks were seen here by me for the first time. The shipping yard is supplied with four cranes; three of 80-ft. span, and one of 95-ft. span, and 20-ft. lift, for loading structural shapes onto cars.

Plate Rolling.

The rolling of plates was only seen carried on at Homestead and at South Chicago. But the recent increase in means of production here has been great. Since 1896, when Mr. Franklin Hilton saw the magnificent mills at Bethlehem Works, which he fully described in the *Iron and Coal Trades Review*, they have been removed, complete as they stood, and erected at Homestead, where they are now running with as much success as ever. The supply of open-hearth basic steel at a cheap cost makes the matter of competing with Homestead an impossible one for others not in possession of such commanding conditions, and this, no doubt, was one of the factors that determined the policy of removing this plant from Bethlehem.

At Homestead classification of work is carried out to a degree of perfection seldom possible at any other works, owing to the large number and variety of their mills. This has an important influence upon the cost of production, and upon the efficiency with which the work is carried on.

For heavy plates the ingots are reduced to slabs, which are cut to weights of plates required, as is the general practice in England.

The slabbing mill is supplied with hot ingots from vertical furnaces heated by natural gas. They are handled by roof-supported cranes, that deliver them on live rollers conveying them to the rolls.

The mill is upon the universal principle, and has two pairs of horizontal and two pairs of vertical rolls driven by two separate

pairs of engines, 30 by 60. There is no tilting of the ingot, and the operation is carried on at a quick speed. No men are engaged at the rolls beyond the lever man. Slabs are sheared by hydraulic shears.

The slabs are re-heated in horizontal furnaces arranged in two semi-circles, with two cranes for charging and drawing for six furnaces. The slab is placed upon the live roller gear of the plate mill. The mill consists of one set of rolls, three-high, and is driven by an engine 42 by 60, with heavy flywheel. There are tables on both sides of the mill, with live roller gear on each. The middle roll is smaller in diameter than the top and bottom; both the top and middle rolls are balanced. The speed is high, and rolling is done without any attention or aid from attendants, besides the table man. An output of 150 tons in twelve hours is easily and frequently obtained.

The plates, when rolled, travel upon live rollers for a long distance, and are marked upon the way to the shears, with but little attention to the surface underneath. Shearing is done by means of castors, standing on pillars as at Bethlehem, and plates are loaded as made, and sent away.

For sketch plates the delay in marking would interfere with the progress of the work, and wooden templates are used to a large extent, in order to facilitate marking: this means additional expense, but it is a mere trifle compared with that of stopping the mill.

With one pair of rolls the surfaces are not so well finished and so perfect as are seen in England, nor is the inspection and testing allowed to interfere with the regular flow of the work.

The most recent addition to the plate-rolling plant has been the 48-in. universal mill. The horizontal rolls of this mill are 30 in. in diameter and the vertical rolls 17½ in. They are driven by a 50 by 60 in. reversing engine, direct connected, and are served by a 50-ton crane of 70 feet span. The plates are rolled off from ingots, and range from 20 to 48 in. wide, $\frac{5}{16}$ to 2 in. thick, and up to 150 ft. in length.

There are six heating furnaces, in two rows, between which are the charging and drawing machines. These are of the low type of Wellman's design, and are driven electrically. The ingots are brought in by locomotives, and the bogies stand in front of the furnace to be charged; the claws grip the ingot endwise, lift it off the bogie, and place it upon the furnace bottom. The furnaces are regenerative, and measure 8¼ by 36½ ft. and have four 6-ft. doors each.

There are two hot beds, one on each side of a line of live rollers, and the plates are moved along the beds by endless chains.

Vertical water-tube boilers with mechanical stokers are used for raising steam.

The plates, on their way to the shears, are passed through a mangle or flattening machine, and are made perfectly flat before shearing.

The largest output in 24 hours, up to the time of my visit, had been 576 tons. Most of the product of the mill was intended for bridge work and pressed steel car building. The edges, as rolled,

were considered good enough for the purpose, and were allowed to pass, though not perfectly straight. The amount of waste was reduced to a very low figure, as practically no side cutting was done at all, and the ends were immediately cut up and placed in

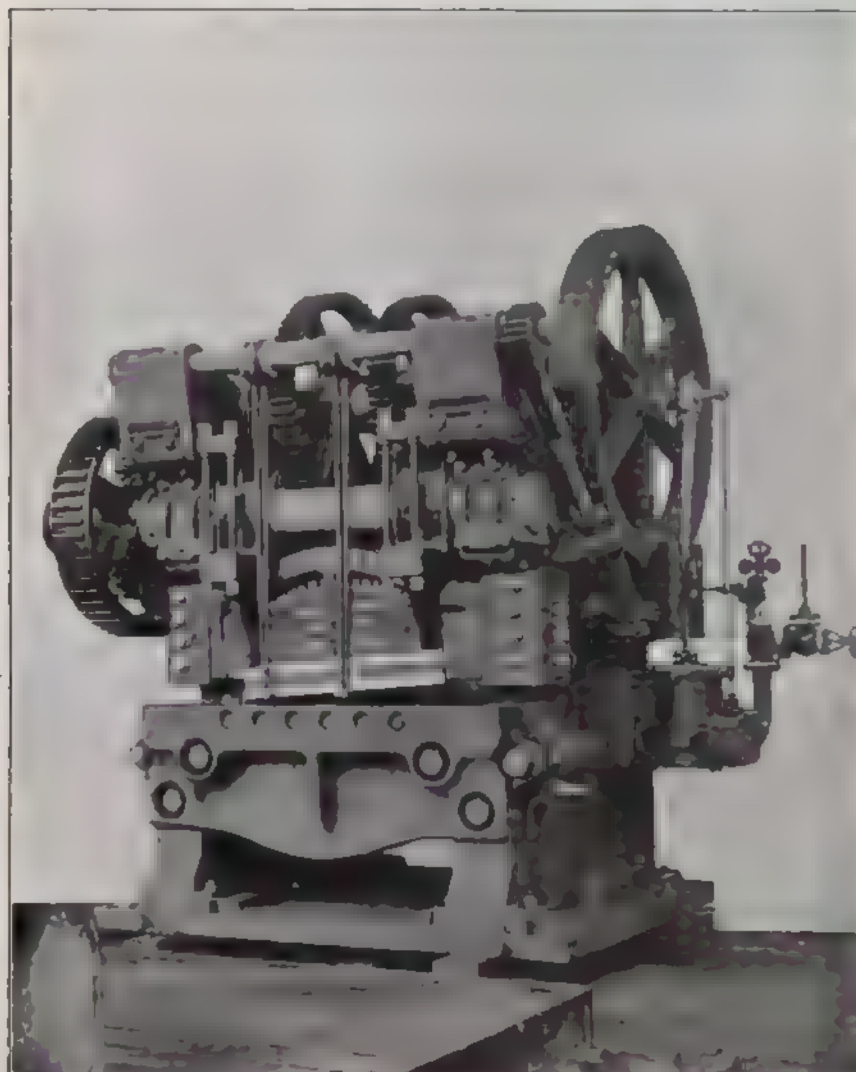

FIG. 23. 60-IN. PLATE SHEAR, TO CUT 2 IN. COLD STEEL PLATES, BUILT FOR HOMESTEAD WORKS.

boxes for charging into open hearth furnaces. The material, in mostly all instances, had to be sent out of the way as made, and if not good enough for the purpose, there was no provision for keeping it on one side to wait for suitable sizes. The number of

hands around this mill was very few, and the quantity turned out would make the product of this mill as cheap as any plate-making plant in the world, providing the ingot cost was the same.

The whole equipment, including buildings, boilers, engines and

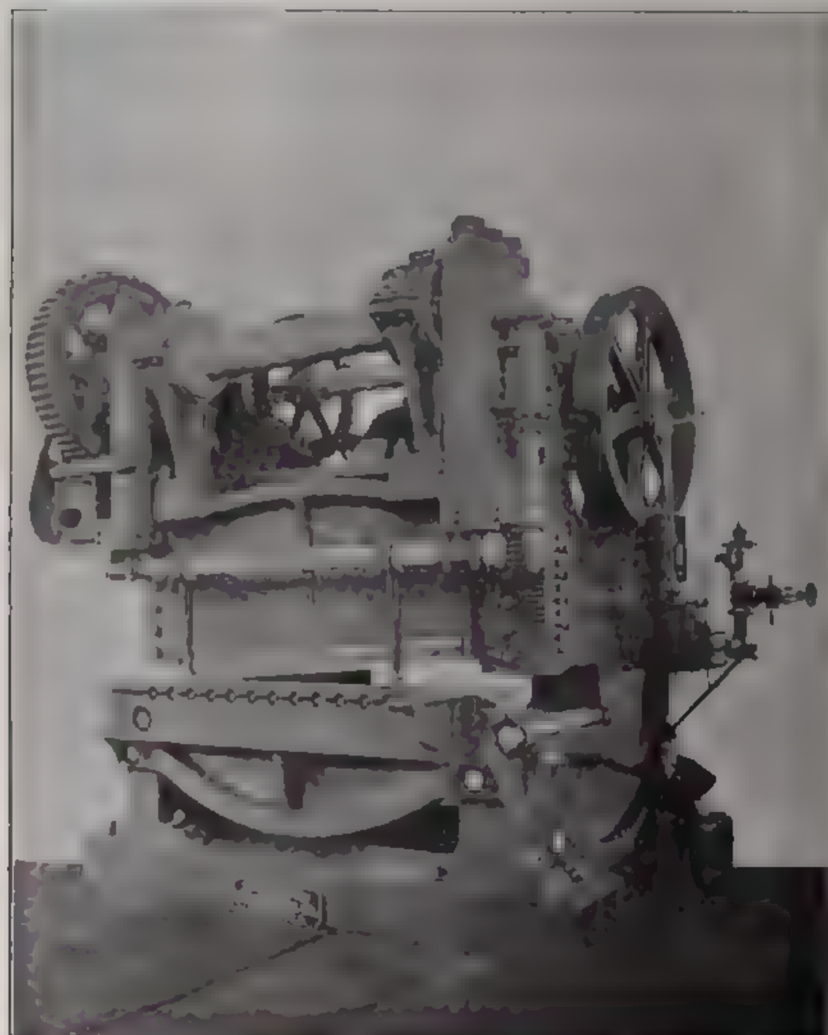

FIG. 24.—132-IN. PLATE SHEAR, TO CUT 2-IN. COLD STEEL PLATES, WITH GAGING ARRANGEMENT.

mill machinery, were of the best possible description; the arrangement was good, and the plant may be regarded as a model for the class of work it has to perform.

The surfaces of the finished plates are not as good as are obtained from chilled rolls, nor are the edges so straight as when

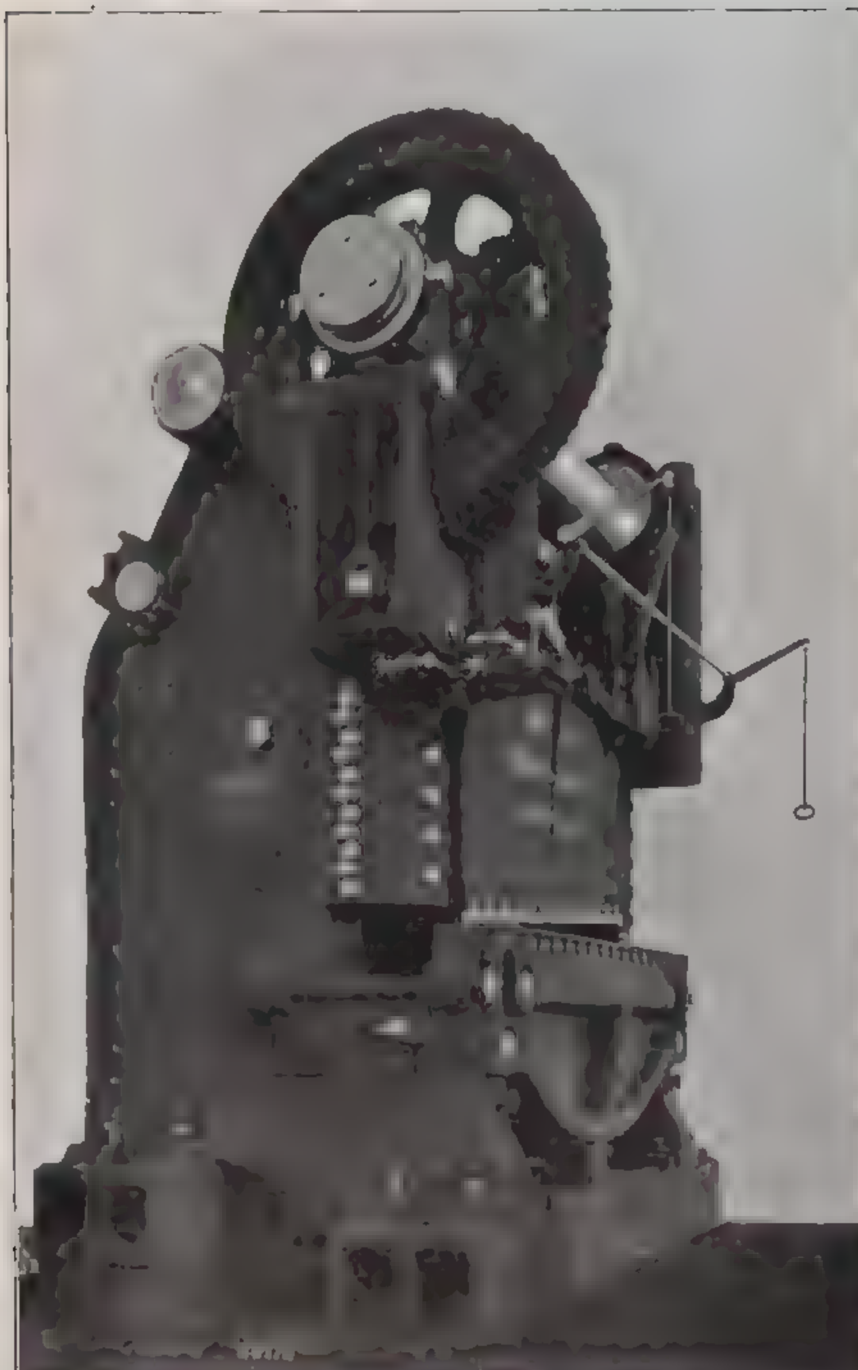

FIG. 25.—132 IN. PLATE SHEAR, SHOWING CLUTCH FOR OPERATING KNIFE HOLDER.

carefully sheared, but the standard of requirement is not so high as with us, and the plates are considered good enough for all practical purposes.

For shearing there are several shears placed at the end of the live roller gear which delivers the plates into shearers' hands. The shearing floor is lowered and the cutting edge of the knife is level with the live roller gear, the plates being supported by castors standing on pillars. The shears differ somewhat from those in general use in England, the knife holder being disengaged by means of a clutch gear as shown in the illustration. For cutting plates up to 2 in. in thickness, a gagging arrangement is operated by means of hydraulic pressure, applied through a shaft carrying two eccentric cams, which give the downward stroke to distant pieces coming in contact with the plates. It is very smart in its action, and causes no delay in shearing, whilst it renders much help to the forkers. The shear blade for side cutting is 132 in. long, and the tool is well made and strongly built, though not so massive as many seen in England for similar work. (Figs. 24 and 25.)

Another shear for end cutting has a blade 60 in. long, with gagging arrangements and disengaging clutch, similar to the other. A feature worth noticing is that shear blades are made with two cutting edges, and are reversible. (Fig. 23.)

The Rolling of Billets.

Four-inch billets are in great request in the United States, and provision is found at all the rail mills for turning them out in large quantities, the arrangements for putting into cars without much manual labour being varied according to circumstances. Several mills were laid out expressly for this purpose, and others are now in course of construction. The new mill at the Cambria Works, Johnstown, is a grand installation in every respect, and would probably run a close race with the other works if supplied with sufficient steel, but six melting furnaces, of 50-ton capacity each, will not admit of fresh records in this direction.

The record is held at present by the 40-in. mill at Duquesne Works, where they have produced 1,478 tons of finished material in 24 hours, and upwards of 30,000 tons in a month.

One of the most recent plants for this work was seen at the Sharon Steel Company's Works, Sharon, Pa. This plant is described fully in the *Iron Age* for July 4th, 1901.

One of the most important blooming mills recently erected in the United States is that which has been built for the Sharon Steel Company, by the Lloyd-Booth Company, of Youngstown, Ohio. (Figs. 11 to 13.) Another notable mill, built for the same enterprise, is the billet mill, supplied by the Morgan Construction Company, of Worcester, Mass. A third set of mills is provided by the same concern to roll wire rods, and there are wire mills and wire nail mills, a tube and a tinplate plant, in addition to each row of wire benches. The mill is driven by a pair of [illegible] cross-compound condensing engines, of the Buckeye type. In the wire and nail mills power is transmitted from the engines to line

shafting by 2-in. ropes. In fact, rope power is used throughout the entire plant of the Sharon Steel Company wherever possible. This was an innovation first introduced by John Stevenson, jun., at the rod, wire and nail mills of the Newcastle Wire Nail Company, at Newcastle, Pa., and with most satisfactory results. Later the rope power system was utilised in the building of the 30-mill tinplate plant of the Shenango Tinplate Company, at Newcastle, Pa.

The wire nail mill is contained in a steel frame and brick building, 1,260 ft. long by 70 ft. wide, in which will be installed 400 wire nail machines grouped in four rows, 250 of which have already been installed. These wire nail machines will be of the German or percussion pattern. Power is furnished the wire nail mill by overhead shafting, which is driven by a 22 by 22 by 40 cross-compound engine of the Buckeye type. The kegs are made in their own keg factory, which is 240 ft. long by 70 ft. span. The kegs are taken by a keg conveyor to the loading department, and after being filled, weighed and headed, are taken to the shipping department and there loaded into cars.

The mill is driven by a reversing engine built by the William Tod Company, Youngstown, Ohio, 46-in. cylinder diameter and 60-in. stroke. The mill is designed to roll 24-in. ingots, and has already done some initial rolling with very satisfactory results.

The blooming mill is 38 in. in diameter.

General Observations.

The workmen at American works are generally supposed to be working much harder than they do in this country, but this is not my own view. After much conversation with many men in various branches who had been employed in similar works in England, and some of them subject to my own control, the conclusion I have arrived at is that the American workmen do not work so hard as the men in England.

They have to be attentive in guiding operations, and quick in manipulating levers and similarly easy work. They are also much more desirous of getting out large quantities than they are in England. All steel plants and rolling mills work longer hours—starting at six o'clock p.m. on Sundays, and keeping running until four or five o'clock on Saturdays. Men are more abundant, and the various operations are so much simplified that an experienced man is not required to conduct any part of the process. They are better paid, and are more regular in their attendance at the works, loss of time through drinking habits, or otherwise, not being tolerated.

More and closer supervision was noted, for the workmen in America do not act upon their own judgment, but carry out the instructions given to them; and labour is sub-divided to such a large extent that each man has an allotted part, and does not interfere with any other.

At some rolling mills, when the least thing goes wrong with the machinery, the roller does not attempt any adjustment, but leaves that to someone else.

The arrangement of plant, and the improvements in methods of

working, have been brought about by energetic and competent superintendents, who have mastered their own conditions, and adapted their tools to the special requirements of each particular case.

The introduction of electric driving has been of great advantage, and has been extensively adopted at nearly every works. At Homestead upwards of 100 overhead cranes were seen in use for all kinds of purposes. It is by the introduction of such tools that it has become possible to deal with about 50,000 tons per week of finished products at Homestead Works, which is about ten times the amount turned out at the largest works in England.

The machinery has undergone many additions and alterations from time to time, and special tools have been designed with great success.

The various inventions of the Wellman-Seaver Engineering Company stand out prominently in connection with the open-hearth and rolling mill departments.

Blowing engines have been improved and increased in efficiency from time to time by such firms as the Southwark Foundry Company, the William Todd Company, of Youngstown, the E. P. Allis Company, Milwaukee, and others. The demand for engines has been so great, and the number of firms engaged in building them has been comparatively small, that the experience gained has been confined to a few engineers, who make a point of not making two pairs alike, if any improvement can possibly be introduced. Compound condensing engines have been developed lately, and some of these represent the best practice; they are very massive and well-proportioned, economical in the consumption of steam, and equal to any amount of driving without incurring any risk, with rigidity in working parts, and excellence of finish in wearing parts; but no attempts are made at high class polish for the sake of appearance, and utility and reliability are aimed at more than showy display.

In cranes, again, the Morgan Engineering Company, of Alliance, Ohio, stand pre-eminent. It devotes close attention to their construction, and makes arrangements for the manufacture of every part, giving the requirements of each case special study, until their cranes have gained a great reputation, and the large number made has given an immense amount of experience within a short space of time.

One great fact was clearly demonstrated—the exact knowledge possessed of the performances of others. Publishing records, and the circulation of information relating to machines, engines, and other parts of different plants, have become general and well-established. Labour-saving machines are watched with care, and no time is lost in following any successful effort at cheapening production.

Information as to actual labour cost was difficult to obtain, but a statement has been made by Mr. Charles M. Schwab, the best possible authority, that whilst the American steel maker paid his workmen twice the amount of money per man paid by the English steel maker, yet the former produced his work at one-third the cost per ton that the latter did. Whilst this may be correct in a general way, it does not appear to be so in the converting of pig-iron into ingots, either at the Bessemer plants or in the open-hearth departments. And it is very

questionable whether the lowest possible costs in America are much, if any, below the actual costs of some of the best in England. In the rolling of ingots into finished material, the introduction of machinery in America makes the difference in this section much more favourable to the American producer, but the repair bill is an item that must be reckoned with, and is of necessity heavy with so much machinery.

The most noteworthy and one of the most important factors in the development and progress of the manufacture, has been the readiness of employers to provide the means of obtaining new machinery. And the desire to have the best of its kind has resulted in the practice of calling in experts in their respective branches to advise on and design different parts of the plant. Thus it is found that Mr. Julian Kennedy, or the Garrett-Cromwell Company, or the Wellman-Seaver Company, are frequently called on to serve some of the largest and most influential firms in the country, who have in their employ large numbers of superintendents and engineers that might be thought equal to any work demanded of them.

The readiness to "scrap" any machine or tool, once it can be shown that a saving can be effected by doing so, is even more remarkable than the desire to buy new machinery. One instance may be given illustrating this fact. An engine builder was asked to supply the best engine for blast furnace hoisting purposes, and he paid a visit to one of the most advanced plants to see what they had at work, and to learn if any complaints were made against specific details, or if any improvement was suggested. Having been shown the best that was at work, the superintendent said he could sell him a better one, which had been ordered for replacing one then in use, but which had never been used. Upon enquiring why this engine was to be sold, the reply came that since ordering the hoisting engine they had introduced an electric winch, and it was so much in advance of the newest steam engine that they had decided not to erect the engine at all, but to order another electric winch at once.

On another occasion, a new Bessemer plant had been erected, and just got into operation. Its productive powers were soon put to the test, and the performance was not so good as that of another plant with converters of a larger capacity. Once this fact was clearly established, the firm that supplied the converters was communicated with, plans for larger vessels were prepared, and a new contract was given out at once. Then a bonus was added for every week that the time specified for delivery could be anticipated; this the maker tried to secure by working night and day until the new converters were finished and set to work.

Much of this promptness of action is no doubt due to the fact that principals are in close touch with the day-to-day requirements, and no delays arise in obtaining the sanction and approval required for the outlay involved. The inventive powers of responsible heads are stimulated to the utmost by this policy, and their advancement depends upon the success with which their ideas and suggestions are carried out. Some huge blunders are made now and again, and their results would probably have discouraged many weaker men, but in such cases

- ..ade in America, and by avoiding previous errors better ess is achieved afterwards.

Dealing with such large quantities of material has a marked ence upon general charges. Directors' fees, and the bank charges ome of the small producers in our own country absorb as much e profit as the total cost of converting pig-iron into ingots; and difference in this important item is more in favour of the American ducer than any other, in consequence of turning out large quantities single establishment.

REPORT MADE
ON THE
BAR AND SHEET INDUSTRIES
AND ON
Primary and Technical Education
IN THE UNITED STATES.

By EBENEZER PARKES, M.P.

INTRODUCTION.

In looking at the conditions of the American iron trade compared with that of Great Britain, it is seen at once that it has many advantages. In the first place, being a new country, America has had the advantage of British experience and inventions, and with the aid of unlimited resources, almost unlimited capital, and a great amount of business aptitude, they have developed the ideas which Great Britain has in the main furnished them with, and so brought their practice in steel manufactures to the highest possible state of efficiency. Such attainments are possible, almost entirely, on the part of the British manufacturer, but he will have to be content to do away with old methods as far as possible, and start with new ideas and new machinery. There are three courses open to the British manufacturer. Either he must stand where he is with his old-fashioned appliances, which in many instances, especially in the Midlands, are as old as the iron trade itself, and so incur the chance of being crushed out altogether, or he may more or less adapt his old machinery by the partial installation of new, and so greatly improve his existing plant. There is no doubt that this latter plan is being followed to a greater extent at the present time than it ever has been before, and the British iron trade is gradually awakening from the self-confidence which had characterised it for so many years. Again, the British manufacturer may begin *de novo*, scrap his plant, and discard the old-fashioned methods altogether, and put down a first-class, modern, up-to-date plant. This, of course, involves two things—boldness and confidence in the future, and a considerable amount of capital expenditure. This question of capital is one in which the American has a great advantage over the Britisher, inasmuch as his home trade is of such enormous magnitude that it first makes him practically independent of foreign customers; and, secondly, his home trade is so highly protected that it is impossible for the foreigner to come in and compete with the American maker. I believe that the third alternative of building a new plant from the foundation is making headway among British capitalists in the iron and steel trades, and although the expenditure is great, there is no doubt that they will reap the benefit in the long run. But we must remember that the American practice is constantly undergoing change, and what is a modern mill to-day may be discarded in twelve months or two years' time and may be supplanted by improvements emanating from the ever active and enterprising engineers of America.

Notwithstanding these difficulties, there is no reason why the English manufacturer should lose heart. There are great possibilities even with the existing plant. The British manufacturer always has been able to overcome difficulties, and if he sets about it in earnest, with that tenacity and courage which is one of his chief characteristics, a wonderful improvement may be made upon the existing state of things in this country.

In looking at the American trade we must remember that the production of iron, in the form of puddled iron, and iron piles in the mill, is almost a thing of the past, although in some departments iron still holds its own and is very much better adapted than steel for particular purposes. It yet remains to be seen how far steel will ultimately and finally replace iron, because there is no doubt that the application of steel to some purposes is on its trial. Complaints are constantly heard of the short life of steel under certain conditions. It would take years at least of thorough tests to decide whether steel is more suitable than iron for some of the purposes to which it is now put. There is doubt that in all cases where steel is exposed to the weather, and where the coating on steel is removed by any action whatever, that the life of steel is infinitely shorter than that of iron, and whether the users of this material will ultimately waken up to that fact and revert to iron remains to be seen. If improved methods could be brought about so as to cheapen the cost of production of iron, and make it of finer quality, there is no doubt that it would have a much better chance in the race of competition with steel. There are makers in America, as well as in this country, who still have a large faith in the future of iron, and believe it will probably come more in favour for purposes for which steel at the present time is used.

Some Merchant Mills and their Accessories.

In the case of the rolling mill practice of merchant mills there is no doubt that the Americans have bar mills of far greater capacity than anything we possess. In fact, so astounding is their capacity that one wonders where the demand is coming from to keep up with the extraordinary output of such mills, if many were put down.

But we must have faith in the future, and go upon the principle that the cheaper the article is produced the greater will be the ultimate demand. There is no doubt that there are almost illimitable opportunities for the English production of iron and steel, if we could only produce it as cheaply as, or more cheaply than, other countries with whom we are competing at the present time. Not that we can hope to find the consumption of iron greatly increased in our own country, but we do hope to find it in the ever-increasing requirements of the world.

One of the most modern examples of the merchant mill is to be seen in Pittsburg; it is a 10-in. Morgan mill for rolling merchant iron at the Duquesne Works belonging to the United States Steel Corporation, which was recently built and laid out on a most thorough and comprehensive plan. The main building in this mill is 870 ft. long by 200 ft. wide, the height to the eaves being 30 ft., and the apex of the roof 60 ft., with a jack roof running the entire length of the whole. This roof, which is a magnificent piece of work, was made by the American Bridge Company. The mill is lighted by

electricity throughout, and is supplied by a travelling crane of 60-ft. span, and of 13 tons capacity. The size of the building devoted to the boiler house is 200 ft. long by 65 ft. wide, containing six batteries of boilers of two each, and 500-h.p. each battery. They are of the Cahall type, and altogether are of 3,000-h.p. There is a purifying plant and a heating and pumping plant for the purpose of supplying water to the boilers. The handling of fuel is done by an electric hoist. The pressure carried on the boilers is 150 lbs. to the square inch, and the size of the main steam pipes carrying the steam from the boilers to the engines is 16 in. diameter. There are also automatic stokers attached to the boilers. As regards the furnaces, they are of the continuous charging and continuous drawing type; length 32 ft., breadth 18 ft., and the height of the roof (which is a patent suspended roof of the Morgan type) is 2 ft. 6 in. to 4 ft. from the furnace bed. They are capable of charging and drawing 86 bars in the hour. In connection with the furnace there is a Sturtevant No. 5 fan, driven by an electric motor of about 13-h.p. This supplies forced draught to the furnace, and also works the mechanical appliances for charging and drawing the furnace. The bars are pushed down the furnace by a steam pusher as required. As far as we could see the billets remained in the furnace from the time that they were charged to the time they were drawn. This was about one hour. The engine which drives the mill is of the Buckeye type, compound, high pressure cylinder 30 in. diameter, low pressure cylinder 54 in., length of stroke 48 in.; weight of flywheel about 20 tons; and the belt necessary for the purpose of driving the different parts of the mill was 60 in. wide. The normal speed of the engine is 70 revolutions, and is so arranged that any speed can be attained from 60 to 100 revolutions a minute. The breaking down of the billet, say, from the 2-in. or whatever size they may use, is accomplished by a set of four or five rolls in a continuous train, and the speed at which they are driven is about two to one of the speed of the engine. The speed of each roll, of course, varies as the billet passes through, and this nice adjustment of speed is arranged first by the gear and next by the altered size of the rolls to suit the requirements of the billet as it is brought down by each successive pass to a smaller size. The bar passes through 10 sets of rollers altogether. After passing through the continuous break-down rolls the bar goes through three short trains of rolls, the first train having 3 revolutions to 1 of the engine, the next train 4 to 1, and the last finishing train about 5½ to 1 of the engine. The necks of the rolls are generally 14 in. long, and 7 in. diameter; the different sets of rolls are separated from each other by long steel spindles coming from the main machinery. The finished bar is delivered on to an incline rack. This rack is one of the most wonderful parts of the mill. It is 450 ft. long, and by a series of horns on the rack, which are moved automatically by machinery, each bar is gradually moved down from the top of the rack to the bottom, by which time the bar is cold, or nearly so. At the bottom of the rack are rollers, and when a sufficient number of bars are discharged into the rollers they are moved forward to the shearing machine, which is placed at the far end of the rack. The bars are cut into the lengths

required, deposited into a large cradle, then lifted up by an electric crane and deposited in a railway truck which is standing close at hand, and which is of 30 to 40 tons capacity. The bars are then ready to be sent to their destination. The output of this mill is something like 200 or 250 tons in 24 hours, and some idea can be attained of the completeness with which the operation is performed from the fact that the whole process from the start to the stage at which the steel is deposited in the truck is all done by automatic machinery, no hand labour being employed. This mill at Duquesne had only been in operation about two weeks when we visited it; they had not got quite straight at that time, but hoped to do much bigger things in the future than they had already done.

Another mill of the same kind, only perhaps not quite so modern, is at Jones & Laughlins, Pittsburg. This firm has the same appliances for automatically charging and delivering from the furnaces. The bar in that case is also rolled in a continuous set of four tandem rolls, passing thence into three sets of rolls. The driving belt in this case is 40 in. wide, and the same belt passes over four sets of pulleys which drive the different rolls in the mill. They claim that they can roll 200 or 250 tons of ½-in. rounds in 24 hours. This is a 10-in. mill. At Jones & Laughlins, also under the same roof, is a larger mill, in which a 5-in. billet, about 18 ft. long, is used. The continuous charging furnace used in this mill is one on which great improvements were made by one of their managers. The railway truck runs up to the back of this furnace, when the billets are picked up by a crane and pushed into the furnace by a pusher, then drawn by mechanism out of the furnace in the usual way. The bars are rolled from 150 to 200 ft. long, and discharged on to a rack similar to that previously described. The crane at the end of the rack is capable of picking up about 30 tons at a time. After being sheared, it is placed in the railway wagon in the finished state. It is claimed that this mill, with good orders running from 1¼-in. to 2-in. rounds, is capable of producing 500 tons in 24 hours. There was also seen at Jones & Laughlins a 10-in. mill, rolling 2-in. angles which can, it is claimed, do about 70 tons a day, but this is looked upon as old-fashioned. Nearly the whole of the furnaces are heated by natural gas, which is brought a distance of about 70 miles. We were told that 8 cents per 1,000 cubic feet of this natural gas was equal in price to coal at about one dollar a ton, but the workmen prefer the natural gas, as it is much cleaner, is thoroughly under control, and heats the iron very regularly. We also saw a large girder mill of three-high rolls, worked by platforms at each side of the rolls. The platform was electrically driven, and could be raised or lowered as required to feed the upper or lower rolls. A question arose as to whether this was better than the reversing mill as we have them in this country, but the manager said it was a debatable point. There is no doubt that the engines running one way continuously occasions much less strain upon both engines and machinery. They claimed to be able to roll 600 to 700 tons of large girders of a good order for a day's work. We also saw at the Homestead Works a 10-in guide mill

which was considered by them as old-fashioned. It was a survival of olden times, and, in fact, one of the oldest parts of the Homestead Works. They use a 4-in. billet cut into lengths of about 150 lbs. weight; in this mill their turn-out is about 90 to 100 tons in 24 hours of $\frac{7}{8}$ rounds. They charge about five tons in the heating furnace at one charge, but this is neither a continuous charging furnace nor a continuous rolling mills; it is a system used by the Homestead people to supply a special quality of steel for which they have a constant demand.

Sheet-Rolling Mills.

Probably the best example to be found in the States of a complete sheet-rolling plant is at Vandergrift, about 30 miles from Pittsburg, belonging to the United States Steel Corporation. The idea of erecting the works in this locality occurred to Mr. McMurtry some few years ago. He selected a suitable spot in the country, close to the Kiskiminitis River, and in the heart of beautiful scenery. The works and the town of Vandergrift are the result of a great conception by Mr. McMurtry and Mr. Vandergrift of taking works away from the town, planting them amid healthy surroundings, and designing a model works and a model town to accommodate the workmen. This is more or less on the lines of several ventures of a similar kind in this country, and is the object of the Garden City Association. But it seems to me that Vandergrift realises to a greater extent, perhaps, than any other experiment of the kind the full consummation of the ideas of the promoters and founders of that town. The works find employment for about 3,000 persons. All of these are housed in the town of Vandergrift, with the result that the town seems to be a perfect ideal as far as the works and the construction and convenience and healthiness of the place are concerned.

The whole process of sheet making, from the output of the steel in the open-hearth furnaces to the galvanising and corrugating of sheets, is carried out in the one works, Mr. Julian Kennedy being the engineer and designer of the plant. Throughout the plant, details are arranged in such a perfect way that one process and one department follows the other in easy succession, so as to bring about the greatest economy of labour. The process commences with six open-hearth furnaces—two basic and four acid. One heat of basic metal takes about seven and a half hours, and one heat of the acid process takes about eight hours. The iron as tapped from the furnace is cast into 5,000-lb. ingots. About 2,500 tons per week are made in these furnaces; and 16,000 gross tons of steel have been made without repairing a single furnace between March and October. Ordinarily, 18 heats a week are produced from the acid furnace, and 13 heats a week from the basic furnace. When the ingot is taken from the pit to the blooming mill it is, in less than five minutes, rolled down in a continuous mill into a sheet bar. The blooming mill engine is by Todd, of Youngstown, and is of 4,000 h.p. This blooming mill is said to be 1,160 ft. long. The roller, engineer, and manipulator work the electric appliances in what is called a pulpit above the mill. The bloom passes through several pairs of rolls before being finished, and by the time it gets to the end of a mill it is cold enough to be

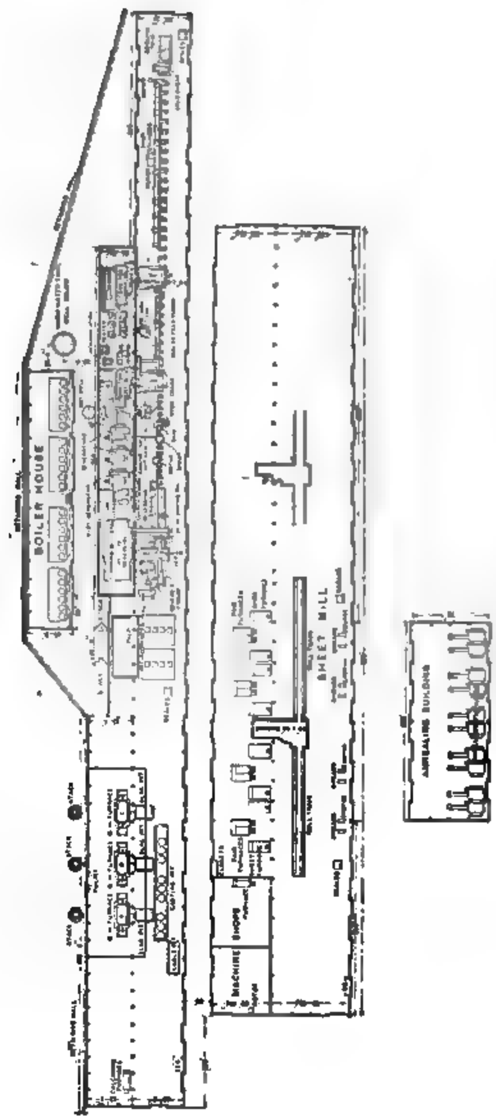

Fig. 1.—Ground Plan of the Sheet Works at Vandergrift.

sheared into the required lengths, which lengths fall into a bath of water. The bars are then picked out of the water and are taken to the mill, ready for charging in the mill furnace. The sheet mill is one of the most remarkable sights to be seen anywhere in sheet-rolling practice. There are altogether 20 mills in one row. One engine operates eight mills, four on each side. Each mill consists of one roughing roll and one finishing roll, besides which there are cold rolls at the end of the train. The engine is a Porter-Allen, 44-in. cylinder, 4-ft. stroke, working at a pressure of 120 lbs. per sq. in., and 80 revolutions per minute, with a fly-wheel of 50 tons weight, and it is supposed to develop 2,000 h.p. There are two furnaces to each mill, one called a pair furnace, in which the bars are heated, and the other the doubling furnace. At the time we were there there were two separate furnaces, but they were designing a furnace by which the heating furnace and the doubling furnace would be combined in one, so that the waste heat from the pair furnace would heat the doubling furnace. These furnaces are fired by gas produced upon the premises. The length of rolls on each side of the engine is about 165 ft. The spindles are 16 in. diameter, and four-way wabblers. The engines are controlled by Porter-Allen governors. The wheels are steel, of the helical type. One of the features of the mill is a machine worked by steam for doubling. The shears are by Bliss & Co., of Brooklyn, and have 142-in. shear blades, worked by a 20-h.p. motor. The whole mill is nearly 1,000 ft. long, but they were in the act of extending the roof and erecting eight or ten more mills. All these mills were being put in the same line. The roughing rollers are cooled by water between the heats; these rolls are carried by a balance. Steel spindles and pinions are used throughout. The sheets, after being sheared, are taken to an immense shop, in which are the close annealing furnaces, about 10 ft. wide; 15 or 20 tons of sheets are placed in each close annealing pot. Altogether 36 furnaces are used for close annealing sheets of all sizes.

After being annealed the sheets are put in the pickling vats, and from there taken successively into the galvanizing department, to the corrugating shop, and to the packing department. Running close alongside this department are the railway wagons ready to receive the cases of sheets. The length of the warehouse is sufficient to take 13 cars standing together. They usually keep a stock of from 2,000 to 5,000 tons of galvanized and corrugated sheets. At the time we were there they were able to produce nearly 2,000 tons a week of galvanized sheets. The power necessary to work all this huge works was produced by 42 boilers of the Cahall type; all the water is filtered before going into the boilers, and the pressure of steam carried is 120 lbs. They are able to produce sheets 144 in. long by 48 in. wide. Running over all the sheet mills is an electric travelling crane, by which all machinery is changed. The rolls are taken out bodily, holsters and all, every week end, another set being ready to put in their place; and then the rolls which require re-turning are turned on the lathe, ready to put back again when required. The rolls are put on to the lathe by the same crane. So quick is a change made in the case of broken rolls that it is said that the whole operation of replacement by a new set has been done in 12 minutes.

In the sheet works under the control of Mr. McMurtry in the Kiskiminitis Valley there are, or will be in a short time, about 54 mills—29 at Vandergrift, 6 at Apollo, 10 at Litzburg, 4 at Saltsburg, and 5 at Hyde Park. At Vandergrift they also make their own chill rolls of very good quality, and which we have reason to believe are being sent to this country for use by English manufacturers; but it must be remembered that the rolling mill practice is different to ours, in so far that all the sheets are made from steel bars instead of piles, and that every mill consists of two pairs of rolls, one breaking down and one finishing, thereby reducing greatly the strain upon the finishing roll, and so tending to increase the length of life of the rolls. Notwithstanding the great production of the American Steel Sheet Company, which is increasing month by month, all their products are readily taken up by the American demand, as sheets are being used to an increasing extent for various purposes, as time develops their suitability.

Vandergrift—A Model Town.

One of the most interesting features in connection with the Vandergrift Works is the way in which the workmen live.

After a great deal of travel in different countries and enquiring into various modes of erection and of laying out a model town, Mr. McMurtry developed the plan of Vandergrift, as it is now in existence. The town is laid out in beautiful wide streets paved with hard brick. The sanitation was the first consideration. A complete system of sewage was established, and the entire town site was supplied with an abundance of pure water, natural gas, and electricity. The men are encouraged to erect their own houses, and after saving a certain amount of money by which they buy the land, they have loans advanced for the erection of the houses. The houses are nearly all detached and cost from 1,500 to 3,500 dols. The land would probably cost about 600 dols. per house. The houses consist generally of a nice entrance hall, two or three reception rooms, a kitchen where the heating and cooking are done by stoves heated by natural gas, three or four bedrooms, a dressing room and a bathroom. Electric light is generally installed throughout the houses, and in some cases at the bottom of the small garden the workman may have a small stable in which he keeps one and sometimes two ponies. The houses are very elegant in their construction and furnishing, and from what we saw of them models of tidiness and cleanliness. The men earn good wages, but the wages go into the house for the comfort and convenience of the family. One special feature of Vandergrift is that there is not a single saloon in the place in which intoxicating drinks are sold. Men, of course, can order intoxicating drink, and have it in the form of barrels or bottles in their cellars, but as a rule—I might say, indeed, the universal custom—there is no indulgence in intoxicating drinks. It was one of the special conditions imposed by the founder that there should be no saloons, and this no doubt accounts for the universal air of prosperity, contentment, and happiness which prevailed. They have a democratic form of government in the town, and most of the governing bodies are formed by working men. The chairman of the School Board is a sheet roller.

Fig. 2. South Side of Grant Avenue, Vandergrift.

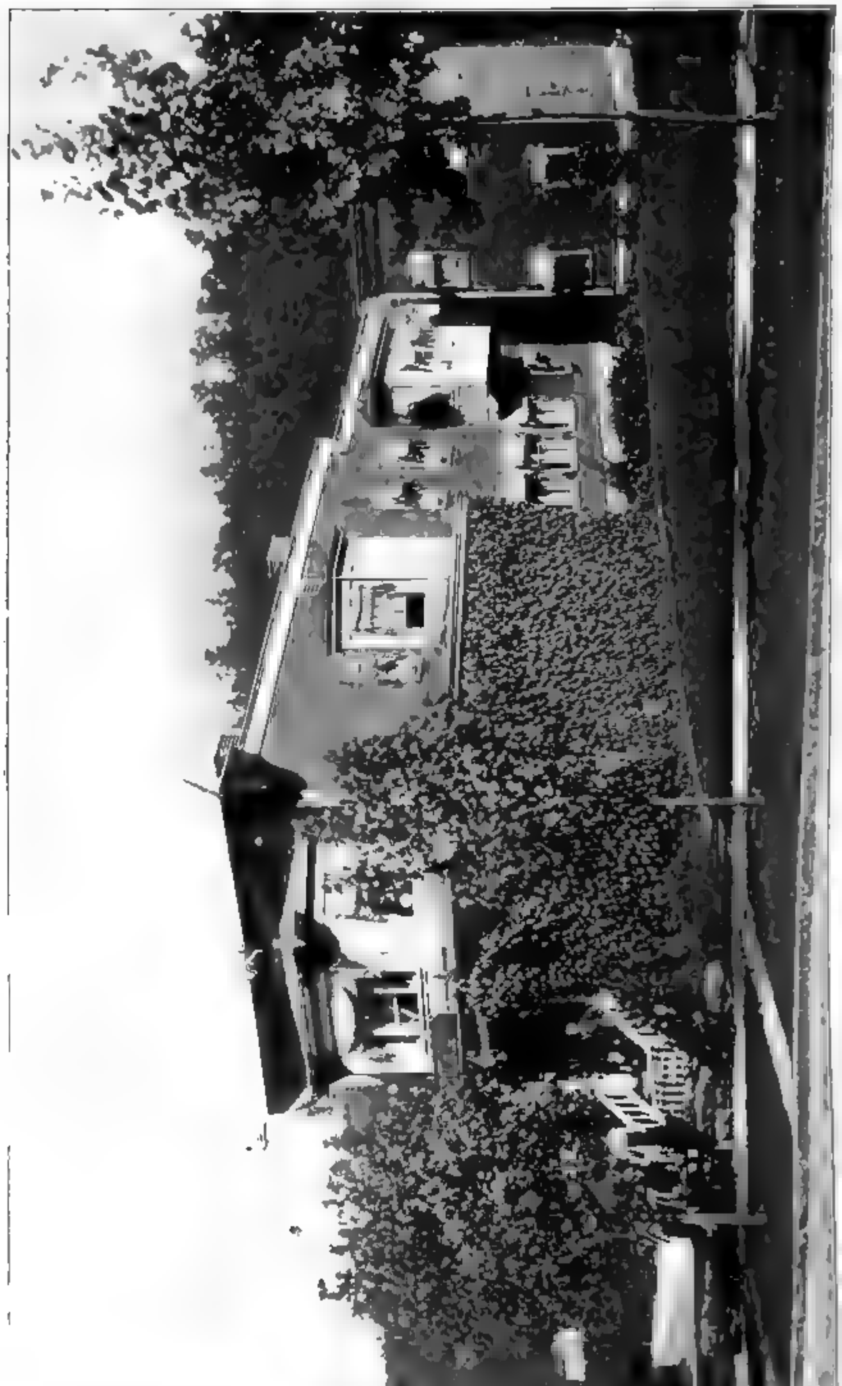

FIG. 3.—THE ONLY INN AT VANDERGRIFT.

FIG. 4.—THE SCHOOL BUILDING, LINCOLN AVENUE, VANDERGRIFT.

Fig. 5. Casino and Library, Vandergrift.

They have churches of all denominations in the town—Methodist, Lutheran, Presbyterian, United Presbyterian, Reformer, Baptist, Free Methodist, and Catholic. There is no Episcopal Church, but a service in connection with that Church is held in the town. Sunday-schools are attached to all the chapels. I asked the question how many policemen were in the town? The answer was one, and he was mostly useful to keep the dogs in order. Two justices of the peace were elected by the people, but no court house seemed to be necessary. The taxes, county taxes, and local tax, amounted to about 20 dols. a year, to cover everything, for a fair-sized house. The men thoroughly approve of no licensed house being in the town, and they say a man can do his work better without beer. The men are drafted into the works, in the first place, mostly from the agricultural districts, and, being naturally sharp and fairly well educated, they learn their trade in an incredibly short space of time. Matching and doubling in the mill, they say, can be learned in a few weeks. A heater can be made in six months, and it took a man who had been working previously on a locomotive from October to the following June to pass through the various stages before he arrived at the position of roller. The reason they gave for this rapid progress in advances through the different stages, and the preferment of such men to higher positions in the mill, was that there is complete freedom in the works. They complained beforehand that when they were under the Amalgamated Society of Ironworkers, they were kept down sometimes for several years at one job, and not allowed to rise. They had no union now, neither did they desire to join any; they wished to stand on their own merits. Therefore they stated that they naturally preferred the freedom from the trade unions which they now enjoy. Education in the town is well looked after. The scholars can stay to 21 years of age, if desired, but they generally leave about the age of 16. They have what is called a casino in the town, which is used for entertainments, and has a library and reading rooms. There are 5,000 books in the library available for all classes of the people. The diet of the inhabitants consists of meat, grapes, pears, peaches, bananas, etc. They have plenty of good wholesome fruit. The leisure time of the men is spent in reading, exercising their horses, coon hunting, base ball, golf, tennis, shooting rabbits and pheasants, and in exercising their dogs. We were told that they scarcely ever lose a day's work from the heat, although it has been known to be over 100 degrees. They have a village band which discourses music on the green whenever there is any holiday or special celebration taking place.

A New Puddling System.

An entirely new departure in the way of puddling is to be seen at Pottstown, near Philadelphia. It is known as the Roe gravity puddler, the invention of an Englishman who went from this country something like 20 years ago, and is now the manager of the Glasgow Iron Company, at Pottstown, Pennsylvania. It is an invention which would interest all makers of wrought iron, and those who believe in it as against steel for special purposes, where welding is required, where the action of oxidation is a consideration, and also where severe

Fig. 6. [illegible]

shocks and vibrations have to be reckoned with. The process in question is designed to produce iron of any desired quality at a cost corresponding to that of steel. It consists essentially in causing a charge of molten iron to flow backwards and forwards in a bath of oxide of iron (melted ore, puddle cinder, or shale) while exposed to the flame of the furnace. The iron and oxide are thoroughly mixed by the sudden stoppage of the motion at each end of the furnace, while the metal is exposed to the action of the flame as it passes from one end of the furnace to the other. By the combined action of these two influences the oxidation of the metal is very rapidly accomplished. While the bath is maintained at a high heat, the backward and forward motion is continued after the iron has come to maturity, and by these means the ball or mass is sufficiently consolidated to prepare it for the squeezer. The furnace now in operation consists of a rectangular box, about 20 ft. long, 10 ft. wide, and 4 ft. high, inside measurements. It is supported on two trunnions placed opposite to each other, at the middle of each side on which the furnace rocks, and through which set of trunnions the flame passes inside the furnace. The bottom and lower parts of the sides of the furnace are formed of water pipes, while the roof and upper parts of the sides are made of fire-bricks. On the bottom and sides is formed a lining of oxide of iron, which protects all the parts of the furnace that are exposed to the wash of the bath. The water pipes cause a certain amount of the oxide of the bath to chill upon them, thus replacing that which has been removed by heat, erosion, or chemical action. This method of forming the lining eliminates the cost and delay of making the bottom by using scrap and fettling in the ordinary puddling furnace, by introducing conditions analagous to those made use of in maintaining the bosh lining of blast furnaces in modern practice. The fuel used in the present machine is crude petroleum, although gas or coal are equally applicable. A jet of atomised oil and air is blown through each trunnion, and the flames meet and mingle in the middle of the furnace, pass to both ends, and find their way out through the stacks, of which there are two at each end. By the method of introduction and withdrawal there is produced a very intense and perfect combustion, together with an equal distribution of flame. One end of the furnace is closed by a door hinged at the top, which is operated by hydraulic pressure, and which is securely brought up tight and locked by means of wedges worked by the same means. The machine is rocked by the medium of pinions working in circular racks, and driven by a steam engine. The method of operation is as follows:—The furnace, having been brought up to heat and properly lined, is tilted, and a charge of molten cinder brought from a small auxiliary furnace is poured into it through the opening in the side of the furnace designed for the purpose. The furnace is then rocked two or three times, to seal the joints of the door, and to allow the bottom and sides to take up what they need. The molten iron is then charged in the same way as the cinder, and the furnace is set to work, rocking at the rate of six oscillations per minute. The bath begins at once to boil violently, and in a few minutes scale is added in quantities determined by the operator. The iron soon comes to nature and collects together, but the oscillations are continued

until all the iron is made, and one ball is properly consolidated within the furnace. The machine is then brought to rest at the desired angle, the door is opened, and the ball shoots out into the squeezer, which has been brought into position to receive it. Immediately after the ball is out the door is closed, the machine is tilted back to receive a fresh charge of cinder, and then is ready to begin a new heat. The present machine was calculated to receive charges of about 3,000 lbs., and no larger ones have as yet been made. The iron is at present melted in a cupola, but when three additional puddlers, which are to complete the plant as at present designed, are finished, it is proposed to bring the molten iron direct from the blast furnace to a storage reservoir, from which it will be drawn as required. The squeezer consists of a main frame supported on wheels that can be brought in front of each puddling furnace to a single discharge point. The squeezing is effected by means of hydraulic rams, moving in two horizontal and in a downward vertical direction. The rams have sectional facing pieces, with openings to allow the passage of the cinder. The bloom as it comes from the squeezer measures 54 by 24 by 12 in., and when the operation is finished it is very solid and free from cinder. The bloom is then taken on a small bogie and cogged down into billets or slabs, which are taken to the finishing mills to be rolled into the desired products, thus avoiding all piling. It is hoped that with greater experience and expertness the wash heat between the squeezer and the cogging mill may be dispensed with. The usual time in making a heat of 3,600 lbs. has been from 30 to 56 minutes, depending upon the kind of iron operated upon; but it is believed that with more experience in handling the oil, the maximum time required for puddling any kind of iron in the furnace will not exceed half an hour. The result so far obtained points to a materially better quality of finished product, both chemically and physically, from a given kind of iron, than it is possible to obtain by means of the old methods. This is an expensive experiment. The cost of the furnace and of the press alone would probably be 40,000 dols., or about £10,000. Some idea may be obtained of the size and strength of the hydraulic press from the fact that there is exerted upon the ball, when in the process of squeezing, a pressure equal to 1,500 tons. If this process comes out the success it deserves to be (and there is no doubt that Mr. Roe has spent an immense amount of time, labour, and ability upon the construction and carrying out of the idea), it will be a complete revolution in the puddling process, doing away with a great many of the expenses connected with the puddling furnace, and dispensing with all the arduous labour which is now expended upon that operation. In that case, it will be a very formidable competitor to the steel products of the trade.

Education.

In estimating the causes which go to make the position of the American nation what it is, the question of education forms a most important feature. This is certainly one of the great factors to take into consideration in accounting for their wonderful progress during the last quarter of a century.

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primary schools are intended to prepare the way for admission
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system of most of the great Commonwealths. The high schools
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nding over four years, and, as a rule, pupils who go to the high
hool graduate at about the age of 18. Attendance upon the high school is not compulsory, but recently, throughout the American Commonwealths, there has grown up a demand, which is increasing every day, that every central population shall have these high school facilities. They are free in the Commonwealth of Pennsylvania, and are maintained in all the large cities and towns.

The Legislature have recently made appropriations by which high schools are to be established in all communities where there is a local population of 1,500 or more. In these high schools the curriculum covers mathematics, algebra, plane and solid geometry, elementary trigonometry, grammar, elementary Latin, and one or the other of two modern languages (French or German), together with elementary physics, elementary zoology, chemistry, mechanical drawing, etc. In the larger cities some of these high schools have advanced to a very high point, insomuch that they have infringed upon the sphere of activity of the colleges. The central high school in the City of Philadelphia, for instance, carries its pupils through a course of study which, when it has been completed, is the equivalent of collegiate training, carried as far as the end of Sophomore year of such

institutions as Yale, Princetown, or the University of Pennsylvania. When the pupils have passed through these elementary schools, there are in the United States some 450 so-called colleges and universities of varying degrees, with entrance requirements as conditions have made them, to which those students who have completed a course in the high school may have access. In some of these institutions education is practically a gratuity—in the Commonwealth of Michigan, for instance, where the only tuition fee that is charged in all its various affiliated schools is £5 sterling per annum. The son of the poorest man as well as the richest in this Commonwealth is entitled to take a course there on the payment of this nominal fee. The same is true of the University of Wisconsin, and of a number of the other great western Commonwealths which wisely applied to educational purposes large land grants made by the Central Government to them in early days; and, as the land enhanced in value, the moneys derived from these sources were turned over to the universities. The result of this arrangement was, at the very outset, a handsome foundation. This has been in later years supplemented by taxation, to which the people have willingly submitted. In addition to this, there are frequent mechanical exhibitions throughout the country which have a great educational tendency. Public libraries have grown up in great numbers in every part of the country. Through the efforts of men like Mr. Carnegie the mechanics of America make great use of these facilities for acquiring knowledge.

In reference to technical education, a great deal has been done in the United States to promote it. Under a provision of the Act of Congress, which is now called the Morrell Act, and was passed in 1862, certain portions of the national domain were turned over to the various Commonwealths, the size of the grant being at the time proportionate to the then existing population of the Commonwealth, to be applied for the purpose of promoting scientific education, particularly with a view to fostering agricultural and mechanical arts. In consequence of this, there has been established in every American Commonwealth a series of colleges, which are commonly spoken of as the Land Grant Colleges. In many of them there is a large preparatory equipment and workshops. The whole tendency of education in these schools has been intensely practical. In all of them has been introduced the laboratory method of instruction. For instance, in the Western University of Pennsylvania, where there are men who take a course of mechanical, civil, electrical or mining engineering, they are required to daily perform a certain number of hours' work in the shops, learning the art of pattern making, of casting, of chipping and filing, planing and sawing in metal, and of tool making, passing on to the construction of models to scale of proposed structures, such as railway bridges, blast furnaces, and all kinds of machinery. This provides for not only a theoretical training, but a good practical one as well.

In the Massachusetts Institute of Technology at Boston there are 1,100 students, whose average age at entrance is 18½ years. It is certain that there are not in all the technical schools of this country as many *day* scholars over 18 years of age as can be found in this one technical school in America. Take, for example, the teaching staff

in the Engineering Department alone of the City and Guilds of London Technical College, where there are three professors, one assistant professor, and 18 lecturers, or a total teaching staff of 22. In the Boston Technical School there are 14 professors, 12 assistant professors, and 43 lecturers, or a total of 69 teachers. The number of students to each professor in Boston is 21 ; in London it is 58.

In the primary schools in America there is no religious difficulty. No minister or clergyman comes in to give Scripture lessons. At the commencement of the school the Bible is read, and occasional explanations are given by the teacher. One particular feature of the elementary schools is the encouragement of thrift among the young people. When a child has saved a dollar, it is entitled to have a bank book, and may deposit its small savings weekly in the bank. Some of them have as much as 70 dols. to their credit in this way.

It will be seen, then, from this review of the conditions which prevail in America, that in some respects they have greater facilities and advantages than we have, among which are the advantage of improved machinery and methods of working ; labour-saving appliances, which are developed to an extraordinary extent ; greater facilities for the conveyance of traffic, both by land and water ; improvements in engines and trucks ; the development of water-ways ; lower railway rates, and greater elasticity in their application to suit the exigencies of the trade ; greater freedom of contract between masters and men ; an educational system which is much more complete and thorough than our own ; added to all of which there is an amount of native energy and a determination to get on and to make the best of their opportunities, which is apparent in all classes ; combined with a system (which is increasing in America) by which men are paid by results. These are some of the causes which place America far ahead of the other steel-producing centres of the world, and conveying lessons to us in this country which I earnestly hope that neither our employers nor workmen will be slow to take advantage of, and which must be embraced if we are to maintain that position among the chief mercantile nations of the world that we have so long enjoyed.

[THE END.]

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